MAR 31 1949

Sky and TELESCOPE

R. W. P. at Stellafane

In This Issue:

★

Vol. VIII, No. 6
APRIL, 1949
Whole Number 90
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Galactic Radio Waves

R. W. P. — Telescope Artist

American Astronomers Report

Northern and Southern Star Charts

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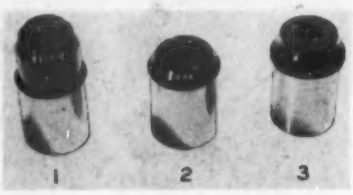

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LETTERS

Sir:

It is a common observation that when a few active and enthusiastic amateur astronomers gather, a wistful discussion of what they can do to help the professional astronomer is likely to arise. There is certainly a worthy eagerness to have their efforts contribute something, however meager, that will be acceptable to the profession. The thinking of amateurs in this direction is likely to be in terms of procuring observational data that will fit into and supplement the observing program of some established observatory. I feel that, praiseworthy as it is, this ambition is for the most part of little avail. Beyond the already widespread observation of the sun and variable stars, possibilities appear to be limited.

The purpose of this note is to propose to amateur societies and the Astronomical League a program of aid to the professional astronomers in a quite different direction. In the course of my limited travels I have always found time to visit observatories that I happen to be near, and I have been impressed by the unvarying courtesy and patience I have been shown and by the eagerness with which the astronomer discusses his work. I believe this arises partly from the fact that astronomers feel their science to be poorly comprehended by the general public and are warmed by any apparently intelligent interest in their studies.

The work of the astronomer is so little understood that, if it is not completely confused with astrology, popular ideas about it are so vague as to constitute nearly complete ignorance. The results of the astronomer's efforts usually filter to the layman slowly and indirectly and perhaps unrecognizably. The thought I wish to express is that amateur societies start an intensive and continuing campaign of acquainting the general public with the work and aims of astronomy. Admittedly, much of this has been done in individual cases, but only sporadically, and its impact on the public as a whole has been rather small.

The proposal, concretely, is that societies undertake aggressively some or all of the

(Continued on page 147)

VOL. VIII, NO. 6
WHOLE NUMBER 90

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APRIL, 1949

COVER: The late Russell W. Porter, in a characteristic pose and engaged in his favorite occupation — chatting with amateurs at Stellafane, in this case, Jim A. Grant, of Mankato, Minn. (center), and George V. Plachy, secretary of the New York Amateur Astronomers Association. Photo by Robert E. Cox. (See page 143.)

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BACK COVER: The south polar axis bearing, yoke, and right ascension drive of the 200-inch Hale telescope, Palomar Observatory, California, drawn by the late Russell W. Porter. Courtesy, California Institute of Technology. (See In Focus.)

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GALACTIC RADIO WAVES

By GROTE REBER

Chief, Experimental Microwave Research Section, National Bureau of Standards

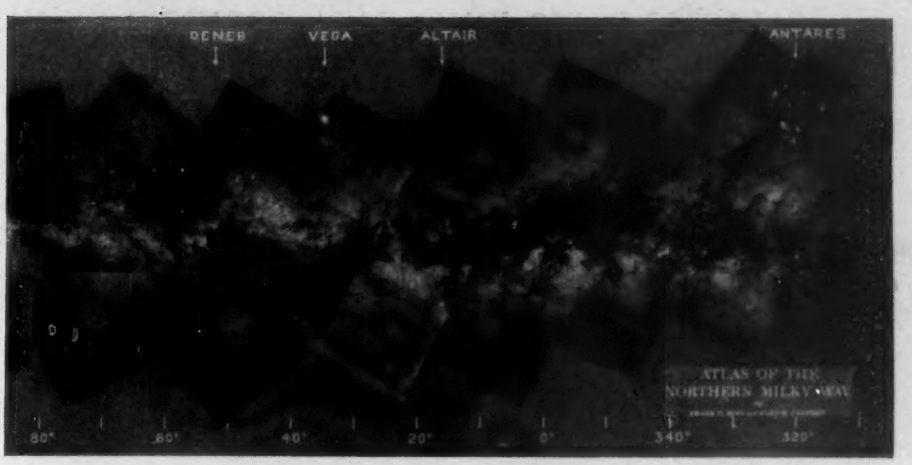

Fig. 1a. The portion of the Yerkes Observatory composite map of the northern Milky Way that extends from Scorpius to Cassiopeia. This map and the one below were prepared by Dr. Otto Struve and Mary R. Calvert from Ross photos.

IN VIEW OF the rather considerable interest shown in radio astronomy during the past two years, it might be inferred that the subject developed as a result of the technological advances of the recent war. Actually, the theoretical conception of this borderline science dates back more than half a century. Hertz's demonstration that long-wave electromagnetic radiation could be produced in the laboratory must have suggested to many minds the possibility that such radiation resulting from natural phenomena might reach the earth from outer space along with visible, infrared, and ultraviolet frequencies of sunlight and starlight.

In 1894, Sir Oliver Lodge gave a lecture before the Royal Institution of Great Britain entitled "Signalling Through Space Without Wires," in which he mentioned that it might be worth while to look for Hertzian waves from the sun. Whether or not this experiment was ever performed and, if so, its outcome do not seem to have been recorded in the literature. However, the equipment then available was so crude that quite some time was to elapse and many improvements were to be made before positive evidence of celestial radio waves appeared in the discoveries of K. G. Jansky[1] in 1931. Oddly enough, this first evidence of naturally produced radio waves was not from the sun but from the Milky Way. This broad band of light, different parts of which cross the northern night sky in summer and winter, is shown as a composite of many photographs in Figs. 1a and 1b.

Although a great deal more energy is received from the sun than from the Milky Way at optical frequencies, the reverse is true for wave lengths of the order of several meters. A satisfactory explanation of this apparent inconsistency must involve some special type of energy transformation occurring in outer space and resulting in the radiation of electromagnetic energy at radio frequencies.

It is well known that the sun and stars are constantly losing small amounts of material driven off by the pressure of light. This material expands and fills the intervening space with a very tenuous gas. When a photon strikes an atom, one or more electrons may be set free from the atom. Thus, under the action of starlight, some of the gas particles become ionized, with the production of positively and negatively charged particles. In the very low-density electron gas that is thus produced, the free electrons may react with the slower positive ions in what are known as "free-free" transitions. That is, the negative particle, upon encountering a positive charge, describes a curved orbit around it in the manner of a comet going around the sun.

In this process, not only is the direction of motion changed but the electron's velocity is reduced, and it seems probable that the reduction in kinetic energy is radiated into space as radio waves from the galaxy. Thus, by this theory the electron gas should appear at radio frequencies as a radiant haze or fog such as one may observe at optical frequencies within a furnace. The column of hot gas rising from the fire will appear brilliant and opaque near the center. No indication of its depth in the line of sight may be secured, and the back wall of the furnace may be at infinity, as far as the observer is aware. At the center the column of gas has an optical depth of unity, but near the edges of the gas the walls of the furnace appear more or less distinct through the bright foreground. In these directions the gas has an optical depth of less than unity. In other words, the physical depth of the luminous material is less than the opacity distance, defined as that distance at which the haze approaches an optical depth of unity.

Now, in the radiant electron haze that we are postulating, the opacity distance will increase with frequency, that is to say, the haze should become more transparent at higher frequencies. Let us also suppose that there are at random places within this haze small condensations of large optical depth or inclusions of high luminosity. These bright objects, which in general will be at some distance from the observer, may be of the same material as the fog, or perhaps of an entirely separate and discrete nature. Thus the intensity-versus-frequency relation of the condensations is quite likely different from that of the main body of the haze. With this series of postulates in mind, let us examine the evidence that is available.

If the observer is surrounded by haze such that the optical depth is unity in

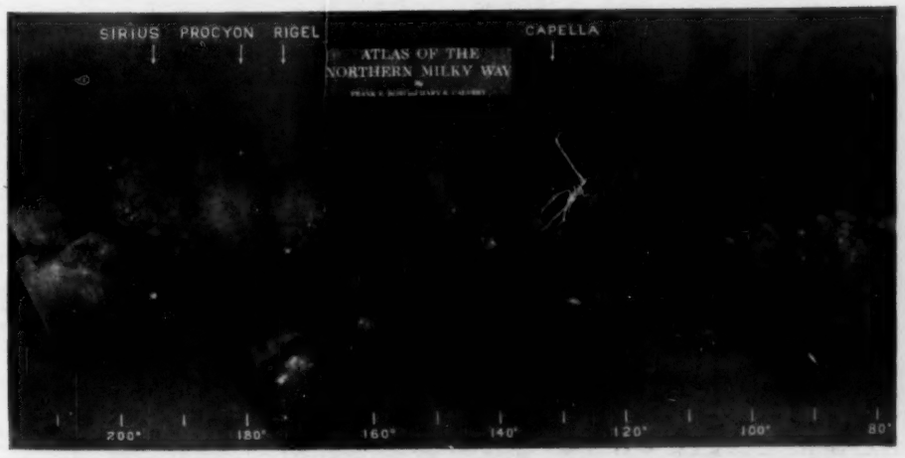

Fig. 1b. The northern Milky Way from Cepheus to Puppis. Yerkes photograph.

GALACTIC RADIO WAVE DATA OBTAINED BY VARIOUS INVESTIGATORS

The charts on this page represent intensity-versus-position data, plotted on galactic co-ordinates. Intensity figures given with the contour lines are in terms of 10^{-22} watts per square centimeter, circular degree, megacycle band. In each plot, the set of data is internally consistent, but cannot be accurately compared quantitatively with sets obtained at other frequencies.

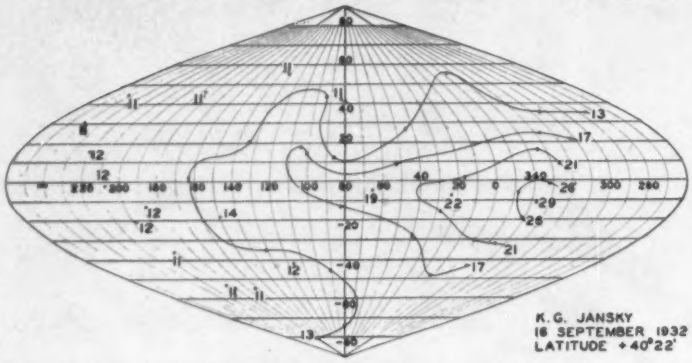

Fig. 2. Data obtained at 20.5 megacycles by K. G. Jansky in 1932 at latitude +40° 22′.

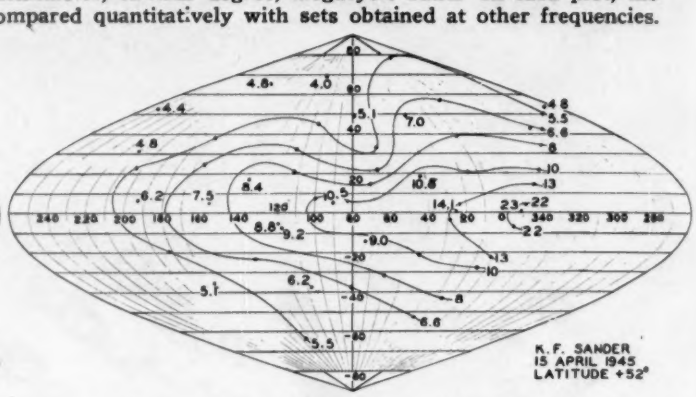

Fig. 3. Data obtained at 60 megacycles by K. F. Sander in 1945 at latitude +52°.

all directions, all parts of the sky will appear equally bright, and no information may be obtained as to the true dimensions of the haze. Fig. 2 is a plot of Jansky's data in galactic co-ordinates on an Aitoff chart. This projection gives equal areas at all places and good relative position or direction at low galactic latitude. It is apparent that at the frequency Jansky was using (20.5 megacycles) the poles of the galaxy are nearly as bright as the equator. Thus the observer merely learns that the haze extends a bit farther along directions near the equator than at the poles.

Using apparatus of about the same resolving power at 60 megacycles, Sander[2] obtained the data plotted in Fig. 3. At this frequency the outlines of the haze are becoming a bit more obvious, the haze appearing to be concentrated more closely toward the galactic equator than at a frequency of 20.5 megacycles.

Fig. 4, a plot of data obtained by Hey, Parsons, and Phillips[3] at 64 megacycles, shows considerably more detail than before as a result of the greater resolving power of their equipment. The effect of going to higher frequencies is indicated in plots of data taken by the writer[4,5] at 160 and 480 megacycles (see Fig. 5). In terms of the "luminous haze" hypothesis discussed above, the data of these various investigators may be interpreted as follows:

1. At very low frequencies the surface brightness of the fog is practically independent of direction. Thus the poles of the galaxy appear nearly as bright as its plane.

2. At higher frequencies the opacity distance increases to a value substantially greater than the thickness of the fog, and the ratio of surface brightness between the equator and the poles also increases.

3. As the opacity distance becomes

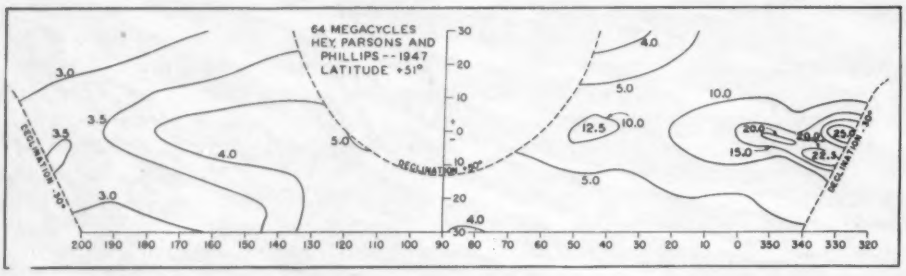

Fig. 4. Data obtained at 64 megacycles by Hey, Parsons, and Phillips in 1947 at latitude +51°.

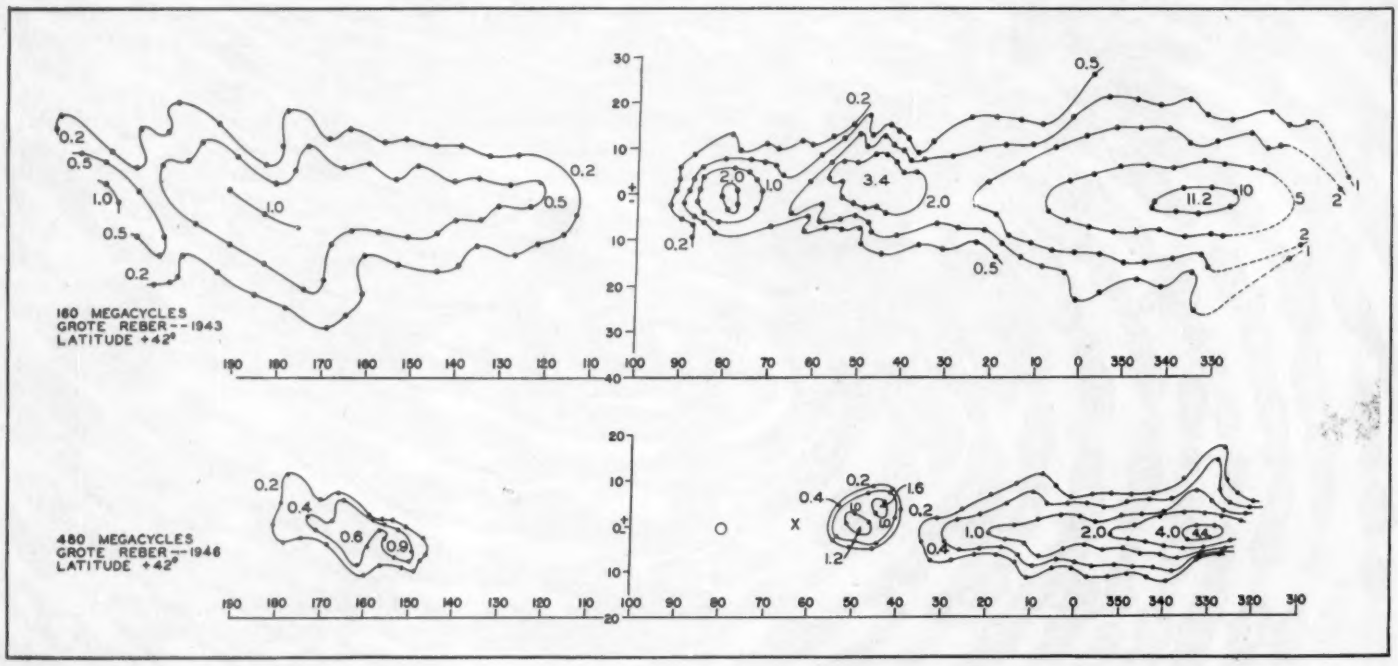

Fig. 5. Data obtained by the author at +42°, the top plot in 1943 at 160 megacycles; bottom, in 1946 at 480 megacycles.

greater, various condensations or places of high luminosity become apparent. The one in Cygnus at galactic longitude 43°, latitude +5°, must be very close to the earth as it is prominent at 60 megacycles[6] and its existence is strongly indicated by the nature of Friis' data at 9.5 megacycles.[7] Furthermore, it must be of high luminosity, as it is easily visible at 480 megacycles. Thus the effective optical depth of this object is large. The Lloyds' mirror experiments over the sea by Pawsey in Australia indicate that the Cygnus source is quite small, probably much less than a degree in diameter.

4. At galactic co-ordinates 48°, 0°, another condensation is apparent. Hey discusses this peak as well as the previous one at some length. Apparently he has considerable difficulty in separating the two at 64 megacycles, as his chart shows a single peak at about 44°, +2°. At 160 megacycles, the resolving power available was still insufficient for separation. However, since spatial penetration at 160 megacycles is quite great, both objects appear of more nearly equal luminosity. Thus the 160-megacycle contours show one wide source near the common center of gravity. At 480 megacycles, the fog is sufficiently transparent to show the 48°, 0°, source clearly. Since at 480 megacycles the two objects are of nearly the same luminosity, it may be assumed that the one at 48°, 0°, is very much farther away than the one at 43°, +5°.

5. The object in Cassiopeia at 78°, −1°, is probably at a considerable distance, since the 20-megacycle data of Jansky and the 60-megacycle data of Sander do not make it visible in the fog while at 160 and 480 megacycles it stands out clearly. Recent work by Ryle and Smith[8] demonstrates this source of radio energy to be present at 80 megacycles and of small diameter.

6. The plot in Orion (140° to 190°, −4°) seems to represent a long, extended arm of the fog. At low frequencies it is not apparent in the general haze, but at 160 megacycles the opacity distance increases sufficiently to show its approximate direction. At 480 megacycles, the opacity distance must be nearly to the end of the arm, which has now become quite small and divided into two fingers.

Fig. 6. A radio-type meridian transit on the author's property at Wheaton, Ill., with which both sets of data of Fig. 5 were obtained. This apparatus is now located at the National Bureau of Standards Radio Propagation Laboratory at Sterling, Va.

7. The situation in Sagittarius is quite complex. At 64 megacycles three small condensations are just visible in the general haze. Apparently they are not far away and are quite transparent. At 160 megacycles we seem to see right through them and into the haze beyond, which is still very bright but more closely associated with the plane of the galaxy. At 480 megacycles the fog is more transparent, but still extends a long distance in the direction of 332°, −2°, which is probably the position of the galactic nucleus. Off toward the north galactic pole is an arm which may be of highly luminous material above the nucleus. Since it is only visible at 480 megacycles, this material must be at a great distance and covered by the fog at 160 megacycles.

8. At 480 megacycles, another object in the region of Aquila (7°, −2°) is just faintly discernible as a swelling of the contours. It does not agree in position with Hey's objects at 64 megacycles and is probably at a very great distance. The resolving power at 480 megacycles is fully adequate to divide it from the nucleus, but the main features are still lost in the luminous haze. To learn more of its details a still higher frequency with greater penetrating power would be required. This object may be the first indication of material on the far side of the nucleus of the Milky Way.

9. At both 64 and 160 megacycles, a saddle occurs in the luminosity near 200°, −3°. Thus we may be relatively near the edge of the haze in this direction. The distinct minimum at 160 and 480 megacycles in the region of Perseus (100°, 0°) also indicates that we are probably close to the edge of the galaxy in this direction.

The results of these investigators give just a glimpse of the wealth of astronomical information that may be obtained through extension of their methods. So far only a beginning has been made in the exploration of this new branch of astronomy. A very important parameter yet to be determined is some yardstick for the measurement of distance. Perhaps by properly studying the Magellanic Clouds some phenomena or set of circumstances may be discovered that will be equivalent to the Cepheid stars of visual astronomy.

To learn more, accurate surveys should be made of the sky in both hemispheres at every 1.50-to-1 interval of frequency from 20 to 1,420 megacycles, a total of 11 surveys. If the results warrant it, these may be supplemented by 10 more surveys at every 1.226-to-1 interval in frequency. From this collection of data the intensity-versus-frequency function of a large number of objects may be obtained. How they appear distinct from the haze and then fade out as the frequency is raised will give some conception of their transparency, size, and distance.

Progress along these lines could best be realized through the establishment near the earth's equator of an observatory given over entirely to radio astronomy. In view of the wealth of astronomical and technical information which could thus be secured, a major scientific undertaking involving a large capital investment is indicated.

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CORRECTION

Dr. Peter M. Millman, co-author of the article in the March issue, "Three-Station Radar and Visual Triangulation of Meteors," calls attention to an error in the illustration on page 115. When the prints were mounted together, we inverted the set of three echoes representing meteor No. 6, at the bottom of the panel. The whole group of three should be the other way up. — ED.

Indexes and Bound Volumes

All volumes of Sky and Telescope are fully indexed, and the indexes are available at 35 cents each postpaid. Send 35 cents in stamps or coin or include with your renewal check or money order. Bound volumes, at $6.50 each postpaid, are also stocked for Volumes II, IV, V, VI, and VII.

SKY PUBLISHING CORPORATION

NEWS NOTES

By Dorrit Hoffleit

OPERATION MAGNETIC

An expedition under Paul H. Serson, of the Department of Mines and Resources, Ottawa, Canada, has confirmed the location of the north magnetic pole at 73° north latitude, 100° west longitude. The party of 14 was in the North from mid-July to September 1, 1948, carrying on studies of the geography, flora, and geology of the region, in addition to the magnetic observations. The expedition's base was at Resolute Bay on Cornwallis Island, which is north of Prince of Wales Island, where the north magnetic pole is now believed to be located.

"INVASION FROM MARS"

After the Orson Welles "invasion from Mars" radio broadcast scare of 1938, it would be hard to believe that such a hoax could anywhere again be taken seriously. Yet a similar one based on H. G. Wells' *The War of the Worlds* was recently reported by the Associated Press to have been even more effective at Quito, Ecuador. So realistic was the call to arms to defend the country against the Martian invaders that the populace responded promptly and hysterically. Not having expected such "success," the artists soon confessed their fiction, whereupon the angered crowds rioted. As the police had gone to repel the "invasion," the army had to quell the riot in which 15 persons were killed and property was damaged to the extent of $350,000.

AWARD TO E. A. HALBACH

Some years ago Mary C. Burr bequeathed to the National Geographic Society as a memorial to her father, Franklin L. Burr, a fund for the establishment of awards to outstanding leaders of National Geographic Society expeditions. At its December meeting the board of trustees of the society awarded a prize to E. A. Halbach, of the Milwaukee Astronomical Society, "in recognition of achievements in the science of geography through leadership of the society's 1948 eclipse party in Burma."

POLARIZED STARLIGHT

Two short papers in *Science* for February 18th present information on the polarization of light from distant stars. Dr. W. A. Hiltner, of Yerkes and McDonald Observatories, employed polarizing equipment on the 82-inch telescope to study a predicted polarization effect in eclipsing binary stars. It turned out, however, that the polarization actually observed (as much as 12 per cent) did not depend on the phase of a binary eclipse, and that it was greatest for certain stars examined in the Milky Way, indicating that the interstellar medium is responsible. Early results indicate that the plane of polarization approximates the plane of the galaxy.

Dr. John S. Hall, formerly of Amherst College and now with the U. S. Naval Observatory, for a time collaborated with Dr. Hiltner, but with a different type of polarizing equipment that he was developing. At Amherst, and this winter with the 40-inch reflector in Washington, Dr. Hall confirmed Dr. Hiltner's conclusions on the interstellar source of the polarization of starlight. He found, however, that there is no preferential orientation of the plane of polarization, that the degree of polarization is strongly correlated with color excess, and that it appears to be the same for all wave lengths.

NARROW ESCAPE

A United Press report of January 27th states that the museum at Bakersfield, Calif., is displaying a meteorite fragment that nearly hit a man when it fell. Russell H. Pigott said that an instant before the meteorite struck a few feet from where he was standing it had flooded the area with brilliant light. Several pieces were recovered, the largest about three inches long and very heavy.

INTERNATIONAL WEATHER CODE

Starting January 1st, most nations of the world began co-operative use of a new and faster weather code. For the weather maps from which forecasts are made several times daily the data are received on a teletype machine — a string of numbers telling the expert the time, place, and all he needs to know about rain, snow, clouds, temperatures, and winds at a given locality. Most European countries, the more advanced Asiatic, Latin-American, South African, and other Southern Hemisphere countries, are all co-operating for better future weather predictions.

SIX FEET OF SNOW!

From George H. Hall, director of public relations for California Institute of Technology, we learn: "They were literally snowed-in on Palomar Mountain for a while this winter, and in fact they had up to 72 inches on the ground at one time. Of course, we always get snow up there in the winter, but not in such goodly amounts as this year. I hasten to add that this is, of course, 'unusual' weather for California."

INDIAN GOLD MEDAL

Dr. Hari K. Sen, Indian mathematician now visiting and lecturing at Harvard College Observatory, has received word from Professor A. C. Banerji, of the University of Allahabad, that the Ministry of Education gold medal of the Indian National Academy of Sciences this year has been awarded to Dr. Sen. It was conferred for mathematical papers adjudged the best published by the academy during the past year. As a former teacher of Dr. Sen, Professor Banerji accepted the medal from Her Excellency, Mrs. Sarojini Naidu, governor of the United Provinces. Professor Banerji is expected to visit the United States in the fall.

NAVIGATION BY SOLAR MICROWAVE

Artificially generated radio energy may not be needed for the accurate determinations of position in navigation during overcast skies, for the sun and stars emit such radiations (wave lengths of the order of half an inch). With suitable receivers it should be possible to utilize these radiations to determine the position of the sun in the sky in all types of weather. According to Science Service, a patent on the basic ideas for this purpose has been granted Dr. George C. Southworth, of the Bell Telephone Laboratories.

PROFESSOR SOMMERFELD HONORED

At its annual meeting in New York in January, the American Association of Physics Teachers awarded its Oersted medal to Professor Arnold Sommerfeld, of the University of Munich. The 80-year-old German physicist is noted for his contributions to the development of the quantum theory and the Bohr theory for accounting for atomic spectra. With the late mathematician F. Klein, he at one time also developed a theory of the gyroscope.

BACK ISSUES WANTED

Copies of **Sky and Telescope** for the months noted here are needed to fill subscribers' requests. For each copy received in good condition we will pay in stamps as follows: 25 cents each for December, 1941; January through June, August, September, 1942; November, December, 1943; January, November, December, 1944. 20 cents each for January, February, April, June, 1945; January, 1946. 15 cents each for February, September, 1948; January, February, 1949.

Place your full name and address carefully on the package in which magazines are shipped, so that refund may be made without the necessity for you to write a separate letter. Address magazines to Circulation Department, Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass.

At Stellafane, near Russell W. Porter's birthplace and atop Mt. Porter, is the turret telescope designed by Dr. Porter and erected by him and the Springfield Telescope Makers. The 16-inch primary mirror, here seen high in the air at the right, has a focal length of 17 feet. The long pipe at the lower left is a counterbalance. All Stellafane photographs are by Robert E. Cox.

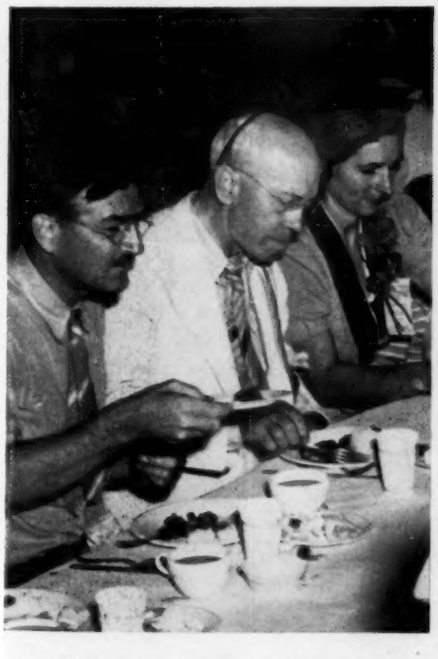
R. W. P.--Telescope Artist

By Leo and Margaret Scanlon
Valley View Observatory

WHEN NEWS of the passing of Russell W. Porter was flashed across the country by wire recently, and terse paragraphs were read throughout the nation by thousands of amateurs, we marked the end of an era of telescope making; for Dr. Porter's stature and position in the field that he created is such that no one can hope or would aspire to fill the vacancy. Held in the highest esteem by professional as well as amateur astronomers and telescope makers, he had unfailing good humor and ready suggestion, keen perception, and was always ready with a quiet word of encouragement. We now look back with greater appreciation of his accomplishments, and study with renewed interest the heritage of advice and suggestion he has given us.

Those of us who enjoy a back-yard telescope have an apt memento of Dr. Porter. (He himself might be the first to say, "Call me Russell, not Doctor.") Our homemade instruments remind us that had it not been for his efforts we might never have had interest nor occasion to view the heavens even with the naked eye. To you, and you, and all of us, he has given a relief from care, a direction to our leisure, and a method of relaxation that is sublime.

He was born in Springfield, Vt., December 13, 1871, of parents in modest circumstances. His father was an inventor and manufacturer, and it was from him, probably, that Russell inherited his talent for mechanics. His early desire was to become an architect, to which purpose he attended Boston Tech. While there he heard a lecture by Robert E. Peary, the explorer, at the old Boston Academy of Music, in which was described the trek across northern Greenland. From that moment his career was altered.



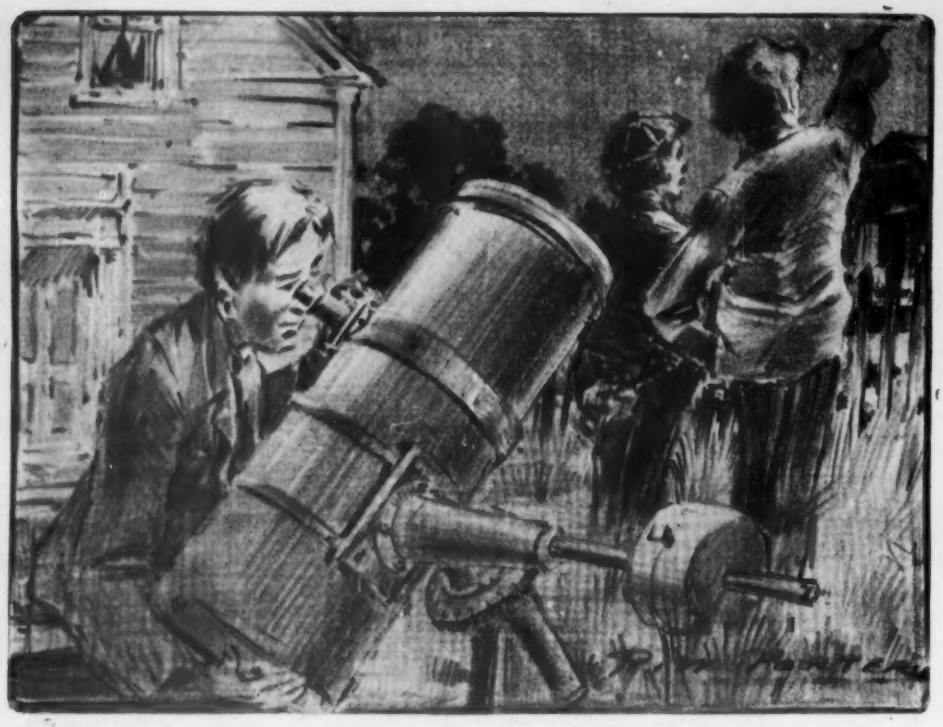
David O. Woodbury, author of "The Glass Giant of Palomar," is shown here with Dr. Porter during "bean time" at a Stellafane gathering.

"I don't know what it was," he wrote. "I had never given the arctic a thought. All I know is that nothing would stop me till I had gone north."

Porter's first of 10 voyages to the arctic was made with Dr. Frederick A. Cook, and not with Peary. The latter had been influenced by Porter's mother to refuse him permission, but since Russell had persisted in his intention to go north, the family thought one voyage would be enough and consented to his accompanying Dr. Cook's party. They started out in a steamer that soon became lost; they ran aground in southern Greenland and tore a hole in the ship. The party was saved, and no sooner was Porter back to civilization than he looked up Peary and asked to be taken on the next expedition. He didn't know how to explain the fascination of the arctic, whether it was the silent desolation, the far-reaching vistas of snow and ice, or the constant struggle for survival against great odds.

In 1901, Porter heard that a man named Ziegler (who had made money in baking powder) was financing a polar expedition. With his usual persistence, Russell went to the commander of the expedition and obtained a job as "assistant scientist and artist." Their first expedition was a failure, but Ziegler financed another on which Porter went "to hear the silence again." Well, he heard plenty, for hardly had the party reached Franz Josef Land when the ice crushed the ship and sank her. The party was marooned for 2½ years (this was before radio) during which time it was Porter's job to take celestial observations to establish their position and to fill in blank spaces on the map. He had ample opportunity to observe the stars.

Finally they were rescued. Porter came back to civilization starved to a skeleton, but with the glory of the polar firmament etched in his brain. A wider horizon than the arctic began calling. During his convalescence on the coast of Maine, in a small fishing village, he won his way back to health, one of the infallible signs of which was his falling



Amateurs in action, as pictured by Russell W. Porter.

in love with the pretty postmistress of the town, Alice Belle Marshall. After their marriage he designed cottages, built them himself and sold them, and so made a living.

His first urge to make a telescope mirror came about 1911, inspired by an article in *Popular Astronomy* written by an obscure coffee merchant named Holcomb, of Decatur, Ill. It was a description of how Holcomb made a reflecting telescope. Through correspondence Porter obtained a little book containing woodcuts of the knife-edge shadows. With some difficulty he followed the directions and made his first reflector, with a 2-inch mirror. He speedily discovered, however, that much of the fascination of making one's own telescope lay not only in looking at the stars with it but in the mechanical perfection which must be achieved in shaping the surfaces of lenses and mirrors to reveal the stars, and in the thrill that comes only to him who can manipulate a piece of glass with his own hands and make its surface conform to his will as well as to the laws of mathematics and optics. This new challenge for Porter was comparable to that of the arctic or of the sky itself.

Prior to World War I, Porter was summoned to Springfield by James Hartness (later governor of Vermont), there to work out the design of precision tools involving optical elements. The war years were spent at the Bureau of Standards doing optical work, after which Porter returned to his birthplace and the Hartness plant. There a dozen men formed a class in telescope making under Porter's instruction and began turning out telescopes for their enjoyment. Alice Porter well remembers those happy times; frequently they would take over the kitchen sink for work with rouge, leaving everything a ruddy mess which stubbornly resisted her efforts at removal. Finally she made the housewife's supreme concession — permitting them to boil their pitch on the kitchen range.

The story is told that one day when Mrs. Porter came home she found that in her absence Russell had cut a hole in the living room wall so that he could thrust the barrel of his telescope through and sit inside to study the stars out of reach of mosquitoes. Russell himself refuted this statement, denying that he ever cut a hole through the living room wall—*it was through his den!*

Lou Lojas (right) and Ed Hanna, of the New York amateurs' Optical Division, asking Dr. Porter his opinion of a model of a mounting for large telescopes that was brought by an amateur to the 1937 meeting at Stellafane.

In 1921, Porter wrote an article for *Popular Astronomy* describing a simple telescope. Among those who read it and became enthusiastic was Albert G. Ingalls, of the *Scientific American* magazine. He was having the usual difficulties that every amateur experiences, and like most of us appealed to the expert, Porter, who later said, "It was a fortunate thing for our fraternity that brought us together, and it was not long before the first thin edition of *Amateur Telescope Making* was published." With characteristic modesty Porter claimed that "the gang is far more indebted to Ingalls' efforts to popularize this hobby than to any contribution made by me. I think my pencil sketches did more to clarify telescope making than anything I have written on the subject."

The "first thin edition" was like a stone dropped into a pool. The widening ripples of interest spread across the country, and within the next two years, amid mountains of correspondence between perspiring aspirants and the authors, a new and greatly enlarged second edition was published. Amateurs had been quietly gathering atop the mountain in Springfield each summer, comparing notes and, more important, coming to meet the man who had given them such an interesting hobby. Soon the crowds became a problem to the members of the telescope making group at Springfield, and the genial Porter journeyed thousands of miles across the country, visiting amateurs en route, to be with "his boys" in August at Stellafane.

For when consideration was being given to the construction of a 200-inch telescope, about 1928, Porter was invited to Pasadena to assist in its design. He had never thought of himself as an astronomer, but December of that year found him settled in California at his drafting board working on "Study #1—Testing Tower of the 200″ Telescope" — his first of thousands of sketches on the Hale telescope. Whenever it became necessary to visualize some complicated structure of the telescope, Porter's wizardry with the pencil was utilized to clarify the blueprints by means of one of his now famous cutaway drawings, one example of which is on the back cover of this issue of *Sky and Telescope*.

The faithful devotion to the development of the Hale telescope, the long hours spent at the drafting board, and the early arduous experiences in the arctic all took their toll of Porter's vitality. Under doctor's orders he paused daily for a siesta as regularly as possible, but frequently sacrificed himself to entertain visitors, especially if they were amateur astronomers. If he were not at home, he could usually be found at the office of the astrophysics

building (which he designed), and it was there we found him one sunny May afternoon in 1940. We were given a most cordial welcome, and since it was a honeymoon trip, Porter availed himself of the privilege of kissing the bride. We were conducted on a tour of inspection of the machine shops and polishing room, later adjourning to his home where for hours it seemed we enjoyed viewing the scores of water colors, pastels, and oil paintings of a wide variety of subjects, including life in the arctic. Generously, Porter invited us to select something as a wedding gift, but after our preference had been narrowed to two distinctly different pastels, between which we were unable to make a decision, R. W. P. just grinned and gave us both of them.

Later that year, in November, 1940, Pittsburgh was observing the centennial anniversary of the birth of "Uncle John" Brashear, the famous telescope maker, and the committee in charge wanted a speaker on the 200-inch telescope. Porter was invited, and with lantern slides made from his cutaway drawings gave one of the clearest insights into the construction of the famous instrument that we had ever had. Of course, most members of the Amateur Astronomers Association of Pittsburgh were present, occupying a table in a far corner of the large banquet hall. As it was arranged, the program did not recognize the existence of our society, an oversight that did not escape Porter. Frequently during his talk he referred to "my boys over there in the corner," and thus encouraged, during a lull in the proceedings we publicly presented him with an honorary life membership in our organization.

Work on the telescope was suspended during World War II, and he thought to enjoy a well-earned rest, but on the contrary Porter's facility with the pencil brought him into greater demand than ever before, and placed a still greater strain upon his already tired heart.

While Porter claimed that his drawings would probably be his monument, there is a much more impressive one atop Palomar Mountain — the dome of the 200-inch Hale telescope. It gracefully portrays in stone and steel the dignity, solidity, and simplicity of its designer. Less conspicuous, but equally important, each amateur astronomer with his homemade telescope contemplating the beauties of the skies pays a humble tribute to the benign influence of the greatest amateur of our time.

This scene at a prewar Stellafane meeting shows the occasion that was for many years the highlight for which amateurs came from far and near: R. W. P. reporting on the progress of construction and optical work on the 200-inch telescope.

THE HALE TELESCOPE PROBES DEPTHS OF SPACE

A six-minute exposure with the 200-inch telescope, made by Dr. Edwin P. Hubble on the night of February 1st, is reported by *Time* magazine (March 14th) to have recorded all the galaxies in an area in Coma Berenices that have ever been observed with the 100-inch telescope. Longer exposures showed increasing numbers of galaxies, with exposure times limited to an hour by sky fogging. Apparently, a one-hour plate reached the predicted limit of the Hale instrument of a billion light-years, as indicated by the number of very faint galaxies recorded.

Dr. Hubble is quoted as saying, "The tests confirm our previous conclusion that the Hale telescope is an unqualified success." Nevertheless, the instrument will not begin a regular observing program until final optical adjustments have been made.

In Focus

CONTINUING the series of drawings of the 200-inch telescope by the late Russell W. Porter, the back cover this month shows the south polar axis bearing, the right ascension drive, and a portion of the yoke mounting.

In the upper center of the picture is the hemispherical thrust bearing of the yoke itself. Like the north horseshoe bearing, it is supported on oil pads, one below and one at each side, through which oil is forced to help "float" the massive 500 tons of telescope. This spherical seat is integral with a yoke that separates and holds the two 10-foot tubular girders. The east girder is cut away to show the means of access to a possible spectrograph farther up in the tube, pictured on the back cover of the January issue.

To the spherical seat is attached a hollow shaft that extends through the right ascension drive wheels. In the center opening of the south bearing is a coude mirror which passes light from an auxiliary mirror when the telescope is pointed north of 50° declination; otherwise, the light goes directly from the main coude mirrors through the south bearing shaft to the temperature-controlled spectrograph room.

The south pier (lower left) has been cut away to show the worms and gears for slewing and tracking with the Hale telescope. Since the desired accuracy of drive is one second of arc in one hour at one revolution per day, and since the short-period errors are limited to 1/10 second of arc per five minutes of time, extreme precision in cutting these gears was required. One second of arc is equivalent to only 0.000445 inch on the pitch circle of the gear. A small motor of less than 1/12 horsepower is sufficient to drive the telescope at tracking speed.

The upper right ascension worm wheel is for tracking at diurnal speed, and the lower wheel is for slewing, to change rapidly from one part of the heavens to another, when a two-horsepower motor is used. The next back cover in the series will show details of the right ascension drive and computer.

Amateur Astronomers

Cleveland Convention Plans Under Way

IN PREPARATION for the annual convention of the Astronomical League in Cleveland on the weekend of July 2-4, Dr. J. J. Nassau, director of the Warner and Swasey Observatory and president of the Cleveland Astronomical Society, announced the appointment of Royce Parkin, Tudor Arms Hotel, Cleveland 6, Ohio, as general chairman of the Cleveland committee. Mr. Parkin has been active in the affairs of the society for a number of years and has served as one of its consultants on literature, publicity, and special events.

Although arrangements are still in the formative stage, it is expected that a comprehensive exhibit of telescopes and accessories produced by members of the league will be displayed in the Case physics building, adjoining the lecture room in which convention sessions will be held. Plans call for a continuing instruments clinic at the exhibit—experienced telescope makers will be available for informal discussions whenever the league is not in regular session.

During the convention an open house program will be arranged at the Warner and Swasey Observatory, which is the home of the Cleveland Astronomical Society. The Junior Astronomy Club of Cleveland has issued a cordial invitation to convention delegates to visit the clubrooms and workshop of the club, which meets at the Cleveland Museum of Natural History, 2717 Euclid Avenue. The club was recently organized to offer expert advice and classroom instruction, by amateurs of the Cleveland area, on the making of mirrors and the assembly of small telescopes. For this purpose a complete workshop has been installed in the museum, where an enthusiastic group of 150 boys and girls and adults has been meeting. The club has been organized under the combined sponsorship of the Cleveland Astronomical Society and the Cleveland Museum of Natural History, in close co-operation with science teachers of the public, parochial, and private schools of Cleveland and vicinity.

In order that members of the league may have opportunity to participate in local popular astronomy in action, David Dietz, science editor of the Scripps-Howard newspapers, has scheduled a public star party for the evening of Saturday, July 2nd, in Wade Park, under the direction of the Cleveland society and the Cleveland *Press*. As in past years (*Sky and Telescope*, III, 12, 3, October, 1944), a large battery of portable telescopes will be set up out-of-doors for the benefit of the public. Those attending the convention are urged to bring telescopes to augment the instruments of the local amateurs. League members will also be selected to participate in the talks on astronomy which will be given over a public address system to an estimated audience of 5,000 persons.

Hotel headquarters for the league will be established at the Wade Park Manor, East 107th Street and Park Lane. This hotel is conveniently located near University Circle and the campus of Case Institute of Technology.

For the information of league delegates who are planning to attend the convention, the officers of the Cleveland Astronomical Society are: Dr. J. J. Nassau, president; Dr. S. W. McCuskey, first vice-president; E. N. Jennison, second vice-president; Mrs. Gertrude Towson, secretary-treasurer; and Paul Annear, recording secretary.

NEW GROUP IN JERSEY

On January 3, 1949, a group interested in astronomy met and organized the West Essex Astronomical Association. Regular meetings will be held on the first Monday of each month at the Grover Cleveland High School, Caldwell, N. J. Robert L. Myrick was elected president; Mrs. Theresa Counihan, treasurer; and D. C. Smith, secretary.

The organization was stimulated by a desire on the part of a few of the members to construct a telescope and also by an interesting course in astronomy taught by Robert Greenley, member of the Bergen County Astronomical Society, as part of the Caldwell adult education program.

D. C. SMITH
19 Francisco Ave.
Caldwell, N. J.

OBSERVERS CLUB IN PITTSBURGH

The Amateur Astronomers Association of Pittsburgh, which has a reputation among member societies of the Astronomical League for the number of telescopes completed by its members, has now gone seriously into observing.

As a direct result of the course in observational astronomy conducted for our members during the fall of 1948, we have created an observers club within the association to put observation on a merit award basis. For the first six months of operation, members will try to outdo each other in observing, identifying and recording as many Messier objects as possible.

To qualify as a "star member" one must submit a report proving he has identified 10 objects listed by Messier; identification of 20 such objects rates becoming a "two-star member"; 50 objects, a "five-star member," and so on. Credit is given for submitting a report outlining the time of observation, power and kind of instrument used, location of the object, and a sketch of the field. The member who submits reports of the most objects before the association's annual picnic in August, 1949, will receive an appropriate award.

The committee selected to pass on reports submitted by candidates consists of Willard MacCalla, chairman; Glen Winterhalter, Leo J. Scanlon, and H. Malcolm Priest.

It will be noted that this observers club is patterned after Messier clubs already in existence (see **Sky and Telescope**, November, 1948, page 17), but other types of celestial objects will be sought from time to time.

CHARLES H. LeROY, secretary
AAA of Pittsburgh

NORTHEAST CONVENTION PROGRAM

The joint committee representing the Bergen County Astronomical Society and the Junior Astronomy Club of New York has announced the schedule for the second annual convention of the Northeast region of the Astronomical League, to be held in New York City at the American Museum of Natural History.

Saturday, April 23

10:00 a.m.	Council meeting
12:00 noon	Registration
1:00 p.m.	Opening address "The Role of the Hayden Planetarium in Astronomical Education," Gordon A. Atwater, curator, Hayden Planetarium
1:30 p.m.	General business session
2:40-4:40 p.m.	Section meetings: Instruments, Programs, Observing
4:50 p.m.	Regular demonstration at the Hayden Planetarium; admission fee 65 cents for adults
6:05 p.m.	Dinner, informal and at places convenient to the museum
8:00 p.m.	Field trips

Sunday, April 24

9:30 a.m.	Council meeting
10:30 a.m.	Business session
11:30 a.m.	Address—"The Center of Our Galaxy," Dr. Bart J. Bok, associate director of Harvard College Observatory.

The registration fee will be $1.00 per person; junior registration fee, 25 cents per person (for members of Astronomical League junior member organizations only). Other details of the convention were published last month in **Sky and Telescope**, pages 117-118.

WILLIAM A. MILLER, chairman
Joint Committee on Arrangements
9 Roxbury Place, Glen Rock, N. J.

ATM'S IN BROOKLYN

Eastern Telescope Makers Association is the name of a new group that has formed to devote its efforts exclusively to telescope making. Two 10-inch telescopes and one 12-inch are being made by the members, and plans call for a 21-inch instrument in the future. At the present time, amateurs living in New York City and vicinity are invited to join by writing to W. R. Cole, director of publicity, 726 East 10th St., Brooklyn 30, N. Y., where the headquarters of the new organization are located. The president of the association is Paul Renaut.

THIS MONTH'S MEETINGS

Chicago, Ill.: On Tuesday, April 12th, John Sternig, of Dearborn Observatory and director of science in the Glencoe public schools, will speak to the Burnham Astronomical Society on "Earth's Next-Door Neighbor, the Moon." The meeting is in the Chicago Academy of Sciences at 8 o'clock.

Cleveland, Ohio: "Our Galaxy" will be discussed by Dr. Freeman D. Miller, of the University of Michigan Observatory, at the April 22nd meeting of the Cleveland Astronomical Society, 8:00 p.m. at Warner and Swasey Observatory.

Detroit, Mich.: On Sunday, April 10th, the Detroit Astronomical Society will meet at 3:00 p.m. at State Hall, Wayne University, to hear Dr. Robert Esling, Wayne University physics department, speak on "Dark Nebulae and the Formation of Stars."

Geneva, Ill.: On Tuesday, April 5th, before the Fox Valley Astronomical Society, "The History and Causes of Eclipses" will be discussed by Carl Bast. The meeting is in the Geneva City Hall at 8 p.m. On Saturday, April 30th, at the society's banquet, Dr. G. P. Kuiper, of Yerkes Observatory, will be guest speaker, with the subject, "Mars, Another World."

Indianapolis, Ind.: At the April 3rd meeting of the Indiana Astronomical Society, Dr. Harry E. Crull, of Butler University, will speak on "A Trip to the Moon," in Cropsey Hall at 2:15 p.m.

Kalamazoo, Mich.: At the home of Dr. and Mrs. L. N. Upjohn, 1556 Long Road, the Kalamazoo Amateur Astronomical Association will hear Dr. Upjohn speak on "Variable Stars," on April 23rd at 8 p.m.

Los Angeles, Calif.: Dr. Jesse L. Greenstein, of the California Institute of Technology, will speak on "Interstellar Matter" at the Los Angeles Astronomical Society meeting, Monday, April 11th, 7:45 p.m. at the Griffith Observatory. This is a change from the regular meeting night due to the eclipse on the 12th.

Madison, Wis.: "The Physical Nature of the Moon" will be discussed by H. B. Porterfield at the April 13th meeting of the Madison Astronomical Society, 8 o'clock at the Washburn Observatory.

Minneapolis, Minn.: At the April 6th meeting of the Minneapolis Astronomy Club, in the Public Library at 7:30 p.m., Alfred D. Johnson will speak on "Celestial Photography with Homemade Instruments."

New Haven, Conn.: Sir Harold Spencer Jones, Astronomer Royal of England, is scheduled to give a public lecture at Yale University on April 18th. The regular meeting of the New Haven Amateur Astronomical Society will be on April 30th, when Mr. Montgomery will speak on "Cosmic Rays." Meetings of the NHAAS are now being held in the Faculty Lounge of the Hall of Graduate Studies, 320 York St., Room 211.

New York, N. Y.: "Mysteries of the Zodiacal Light" is the subject for discussion by Dr. Charles H. Smiley, of Ladd Observatory, at the April 6th meeting of the Amateur Astronomers Association, 8:00 p.m. in the American Museum of Natural History. The 22nd annual dinner of the association is scheduled for April 22nd.

Pittsburgh, Pa.: The speaker at the April 8th meeting of the Amateur Astronomers Association of Pittsburgh, 8 o'clock in the Buhl Planetarium, will be Phillip S. Neal, formerly a captain in the Corps of Engineers, Northwest Service Command, U. S. Army. He will present an illustrated tour of the Alcan highway.

San Diego, Calif.: "Meteorite Showers, Meteors, and the New Method of Their Study" will be discussed by Carl Dickson at the San Diego Astronomical Society meeting April 1st, 7:30 p.m., Room 504, Gas and Electric Building.

Stamford, Conn.: At 8 o'clock on April 15th, meeting in the Stamford Museum, the Stamford Amateur Astronomers will show moving pictures on astronomical subjects, including the new film, Solar Prominences.

Washington, D. C.: Dr. Fred L. Whipple, of Harvard College Observatory, will speak on "Meteors" at the meeting of the National Capital Astronomers on Saturday, April 2nd, at 8:15 p.m. in the Commerce Department auditorium.

Awards for winning entries in the third annual science fair, sponsored by the Washington Academy of Sciences and affiliated societies and Science Service, and conducted in junior and senior high schools by the science teachers of the District of Columbia, will be made at this meeting.

LEAGUE ACTIVITIES CHAIRMAN

Rolland R. LaPelle, of 54 Fernleaf Ave., Longmeadow 6, Mass., a member of the Springfield STARS club, has been appointed chairman of activity sections of the Astronomical League, to serve until July. Meetings of the league's national council, to be held during the Northeast regional convention in New York this month, have been called by the president, Mrs. Helen S. Federer, and Mr. LaPelle has been asked to meet with the council to discuss and formulate plans for activity sections within the league.

LETTERS

(Continued from page 138)

following activities: Establish friendly relations with local newspapers, for obvious reasons. Provide speakers for luncheon clubs, church groups, women's clubs, and functions where intelligent people gather, and solicit invitations to use this service. Make good amateur telescopes available to the public, frequently and continuously. Co-operate with the public library to keep reliable up-to-date books displayed and, equally important, to keep obsolete books out of undiscriminating hands.

I believe if a campaign of education were carried on widely enough and intensively enough to make an impression on the general public, the amateurs would win a sincere vote of gratitude from their professional brothers.

R. D. COOKE
258 Ruby St.
Joliet, Ill.

AAVSO SPRING MEETING

The annual spring meeting of the American Association of Variable Star Observers will be in Providence, R. I., at the Ladd Observatory of Brown University, at the invitation of Dr. C. H. Smiley and the Providence Skyscrapers, on Friday and Saturday, May 27th and 28th.

An illustrated lecture Friday evening will be by Harries-Clichy Peterson, a member of the Finn Ronne antarctic expedition. Saturday morning a business session will be held on the Brown campus, followed by the society luncheon at noon. A trip to the Seagrave Memorial Observatory of the Skyscrapers is scheduled for Saturday afternoon, where the meeting will conclude with a picnic supper.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evenings, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill. Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m.; Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays; 11 a.m. Saturdays, Children's Hour (adults admitted). Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. (Closed July to mid-September.) Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Tuesday and Sunday, 4 p.m. Special showings by request. Admission free. Spitz projector. Director, Ernest T. Ludhe.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 80th meeting of the American Astronomical Society at New Haven, Conn., in December. Complete abstracts will appear in the Astronomical Journal.

Remote Cepheids

TWENTY YEARS AGO, Walter Baade, now of the Mount Wilson Observatory, discovered four very distant Cepheid variable stars in Cygnus, all of them within four degrees of the equator of the Milky Way. Subsequent investigations in Holland by Oort and Oosterhoff proved that these stars showed small evidence of interstellar reddening, thus suggesting high transparency for the direction of the great star cloud in Cygnus. To confirm and extend these early results, the region was placed on the regular observing program of the 24-33-inch Jewett Schmidt telescope of Harvard Observatory's Oak Ridge station. On 37 nights, pairs of blue and red plates were taken, and blue and red standard magnitudes were derived from numerous comparisons with the known polar sequences of standard brightnesses.

From these plates, Dr. Bart J. Bok and Margaret 'Olmsted find that the transparency of the region is slightly less than previously thought, but that the interstellar obscuring medium still permits direct transmission of 10 per cent of the original starlight for stars at 25,000 to 50,000 light-years from the sun, which is the tremendous range of galactic distances represented by these four variable stars. The investigation is another illustration of the space-penetrating power of the moderate-sized Schmidt cameras. With the aid of a series of two nightly photographs of 10 minutes exposure each, it has been possible to make a detailed study of the light and color variations of stars as far as 50,000 light-years from the sun.

History of a Pleiad

PLEIONE, seventh brightest of the Pleiades, situated east of Alcyone and close to Atlas, is a 5th-magnitude star designated 28 Tauri by Flamsteed. After finishing a more extended photometric program on the Pleiades, Dr. L. Binnendijk, now of Sproul Observatory, collected all available magnitudes of Pleione, which has been known as a variable since 1937. Its brightness was measured at Leiden on 14 plates, and at Rutherfurd Observatory on 64 Yerkes and five Sproul plates, and extensive observations by Strassl at Goettingen and by Calder at Harvard were reduced to the same photographic system.

The light of this star was slightly variable prior to 1937, at which time a sudden decrease started, amounting to half a magnitude by 1939. From 1942 on, the star was again slightly variable, averaging 0.2 magnitude fainter than the average prior to 1937. In 1939, too, the star was found to be slightly reddened, and it was still somewhat redder than normal in 1944. From 1888 to 1905, Pleione was known to be a star with bright emission lines in its spectrum, but in 1905 the hydrogen lines appeared only in absorption. It was not until 1938 that the hydrogen emission reappeared, together with sharp metallic lines not normal to a star of spectral type *B*8.

Pleione is now known as a shell star, and all the above facts indicate that a shell of matter was ejected from the star in 1936. According to this viewpoint, the decrease of light during the period 1937-1939 was caused by the absorption of the star's light in the shell material. At the moment, we may still be looking through some of this material.

Colors of Galaxies

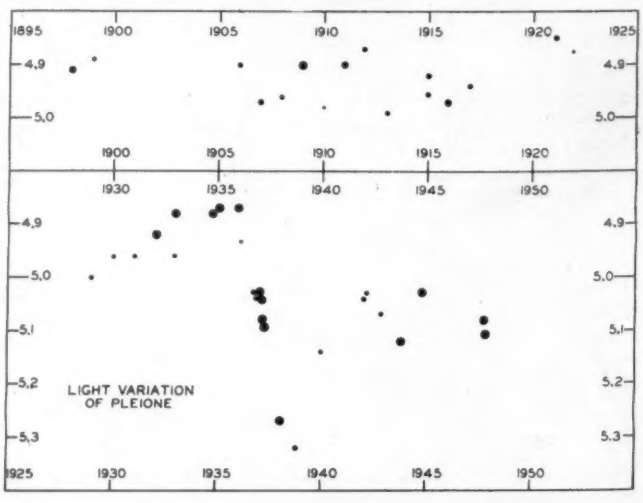
ASTRONOMERS have known for years that nearby red supergiant stars, such as Antares and Betelgeuse, are spendthrifts, and because of their relatively short lives must be younger than the sun. These young stars are presumed to have condensed "recently" out of the gas and dust present between the stars of the Milky Way, and of other spiral galaxies. In nearby galaxies of the elliptical type the red supergiants apparently are absent.

In the Corona Borealis cluster of galaxies, 130 million light-years distant, are located the most remote examples of spiral nebulae whose distances are known. Therefore, Dr. A. E. Whitford, of Washburn Observatory, made color measurements of four elliptical and seven spiral galaxies in that cluster with photoelectric apparatus on the 100-inch telescope at Mount Wilson Observatory. The previous colors in clusters of galaxies reported by Dr. Joel Stebbins and Dr. Whitford showed an unexplained excess of reddening (*Sky and Telescope,* VII, 123, March, 1948), but the objects measured were all galaxies classed as elliptical rather than spiral.

The four ellipticals showed an international-scale color excess (reddening) of +0.28 magnitude, of which 0.15 is not accounted for by the expanding universe red shift. Intermediate-type spirals also showed a residual excess, but the interpretation is clouded by uncertainty about the classification of these objects at such a great distance. Four spirals are classified Sc, however, the most open type of galaxy, and these show a mean color excess of +0.09, which is even less than that expected from the ordinary red shift. In other words, the spirals appear about as red as expected, while the ellipticals are responsible for the excessive reddening originally discovered by Stebbins and Whitford, as mentioned above.

Dr. Martin Schwarzschild, of Princeton, has suggested that inasmuch as we see the Corona Borealis cluster as it was 130 million years ago, we may be seeing also the red light from supergiant stars which have since consumed their store of energy and died. Nearby ellipticals, seen in their "later years," show no such evidence of containing giant red stars. Thus, it may be that these non-spiral systems lack the raw material for new stars, and any supergiants originally present have therefore not been replaced, and have gradually become extinct.

The interpretation placed on the



The light variation of Pleione from 1897 to the present, from data compiled by L. Binnendijk, of Sproul Observatory. Winter or monthly means are plotted for each observer, larger dots representing more accurate observations. The slight variability of the star prior to 1937 and the sudden decrease of half a magnitude by 1939 are clearly shown.

present observations means that by studying the more distant galaxies accessible to large telescopes it is possible to go backward in time sufficiently to reach what Dr. Whitford termed the "Goetterdaemmerung era," and to detect the aggregate light of stars now long since dead. In this way, certain effects of stellar evolution may be observed, although the processes are far too slow to be noticeable in any single star over the interval that it has been watched by humans.

Galactic Radio Energy

IN A SYMPOSIUM on microwave astronomy, Dr. Jesse L. Greenstein, of California Institute of Technology, discussed alternate theories to explain radio energy received from stellar regions. The total energy in galactic radio noise is very small compared to that in light or in cosmic rays. Nevertheless, if a source were at the distance of the nearest star it would require 10^{18} kilowatts to equal the observed intensity.

Radio energy of sufficient strength may come from electromagnetic storms in the outer atmospheres of stars, or even from a few very peculiar stars that emit a large fraction of their energy in radio frequencies. This idea gains some support from the observation of a few small regions of the sky that appear to emit signals of variable field strength. The upper layers of the sun, near sunspots, radiate strong, variable signals. But average stars would have to emit 100 billion times as much radio energy as the sun does to account for the observed intensity. Therefore, only extraordinary stars could fulfill the conditions required by this theory.

On the other hand, between the stars there is a not-quite perfect vacuum which contains about 20 hydrogen atoms per cubic inch. Far from hot stars this gas is neutral and cool, but near them it is ionized into protons and electrons and has a temperature near 10,000 degrees absolute. The hot regions appear as very faint gaseous nebulae in the Milky Way, and they can be sources of radio energy. By analogy with the Andromeda galaxy, they may be concentrated only in the thin spiral arms of our system. In between the arms of M31, Baade has found that no absorbing dust appears to be present, and the hot stars capable of ionizing the hydrogen and making it emit radio waves occur only in the spiral arms.

Since dust obscures the light of stars in distant arms of our Milky Way galaxy, it may be possible to locate those arms best by radio exploration. The great intensity of the radio signals from the galactic center direction may be interpreted as due to several inner spiral arms at large distances from us. The Cygnus maximum, according to this theory, would arise because we look along an arm for a great distance and, therefore, through a great amount of ionized hydrogen. But this and the first theory both await further observational evidence of a highly directional nature before they can be rejected, accepted, or modified.

Magnetic Oscillations of a Star

THE GENERAL magnetic fields of stars do not seem to be very constant. At Mount Wilson Observatory, Dr. Harold Babcock (father) found recently that the general magnetic field of the sun is probably variable, while Dr. Horace Babcock (son) has discovered a star with a magnetic field of several thousand gauss that changes periodically in nine days from north to south polarity and back again.

On the other hand, the theoretical work of Cowling in England had shown that the magnetic field of a star would change only extremely slowly (less than one per cent in a million years) if the hot gases inside the star were entirely quiescent. However, Cowling himself and others have pointed out that even the slightest streaming about of the gases may produce fast changes of the magnetic fields.

In particular, Alfvén in Sweden has found that a new type of oscillation, called hydromagnetic waves, may occur in magnetic stars, oscillatory movements of the gases being closely coupled with fast changes of magnetic field. Dr. Alfvén only considered hydromagnetic waves of fairly small extent for the purpose of explaining the phenomena of sunspots.

The paper presented by Dr. Martin Schwarzschild, of Princeton University Observatory, reports on his investigation of waves of large scale that extend throughout an entire star. In these waves, the gases are found to move back and forth in characteristic stream-motion patterns while the magnetic field of the whole star changes periodically. It now appears possible that the strong magnetic variations of some stars may be understood in terms of hydromagnetic waves of large scale.

TERMINOLOGY TALKS

J. HUGH PRUETT

Limb, Terminator, Cusp

ALTHOUGH known most commonly as lunar terms, these expressions are quite applicable to many heavenly bodies. *Limb* refers to the circular outer rim of an orb as seen from our location in space, or, in the case of a star, as we believe it exists. If the entire side of a body facing our direction is not brightly illuminated, as on occasion those of the moon and some planets when lacking the full phase, the dividing arc between the light and shaded portions is known as the *terminator*. *Cusps* are "pointed ends," and in the cases of the moon and some planets are the apparently sharp ends, or horns, of the crescents.

Old Moon in New Moon's Arms

An evening or two after we first notice the "thin slip of a new moon" hanging in the western twilight, our lunar neighbor remains above the horizon long enough before setting to appear in a fairly dark sky. Then nearly every month someone, observing more carefully than ever before, inquires why the entire circular disk of the moon may be seen: a brilliant crescent rimming the side toward the sun, and all the rest only very faintly illuminated. This has long been known as "the old moon in the new moon's arms." With telescopic aid, this combination surrounded by the rich blue of the twilight sky forms a most beautiful picture. From night to night as the crescent widens, the dim part becomes more difficult to see. By first quarter, it is usually invisible without optical aid.

What makes this dark section of the moon dimly visible? It is the side turned away from the sun, so it gets no direct light as does the crescent part. The moon has no atmosphere sufficient to bend light into its twilight zones, and the faint illumination is *earthshine*, pure and simple. This dark side of the moon is in the lunar night, but a mythical moon man would behold an almost full earth beaming gloriously out in the crystal-clear sky, an earth over 40 times brighter than the full moon ever appears to us. No wonder then that earth dwellers can see—although faintly— this brilliantly lighted nocturnal moonscape.

The earthshine appears to grow dimmer from night to night for two reasons: the increasing area of the brilliant part of the moon blinds us more to this dim light; and, since the earth is changing from the full toward the new phase, it is actually giving less light to the dark side of the moon.

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BOOKS AND THE SKY

A CONCISE HISTORY OF MATHEMATICS

Dirk J. Struik. Dover Publications, Inc., New York, 1948. Vol. I, 123 pages; Vol. II, 176 pages. $1.50 per volume.

THESE two attractive, well-illustrated books give a concise but very readable account of the history of mathematics up to 1900. The first volume, consisting of five chapters, begins with the first conceptions of number and form in the Old and New Stone Ages. Chapter II is concerned with the development of mathematics in the ancient Orient and emphasizes the superiority of the Mesopotamian over Egyptian mathematics. Chapter III explains the reasons for the rise of Greek mathematics, which not only asked the Oriental question, "How?" but also the modern scientific question, "Why?" The closing two chapters of this volume are concerned with the Orient after the decline of Greece and the beginnings in western Europe, ending with the discovery of logarithms by John Napier. Volume II, consisting of Chapters VI, VII, and VIII, is devoted to the development of mathematics in the 17th, 18th, and 19th centuries, a discussion based mainly on persons and schools, rather than on subjects.

Professor Struik does more than state facts and dates. He gives the reasons certain mathematical developments and discoveries came when they did, why some civilizations were productive and others sterile in the field of mathematical discoveries. The impact of astronomy on mathematics is particularly striking. "Mathematics throughout its history and until modern times cannot be separated from astronomy. The needs of irrigation and of agriculture in general—and to a certain extent also of navigation—accorded to astronomy the first place in Oriental and in Hellenistic science, and its course determined to no small extent that of mathematics. The computational and also often the conceptual content of mathematics was largely conditioned by astronomy, and the progress of astronomy depended equally on the mathematical books available." The astronomer meets many old friends in these volumes: Eratosthenes, Ptolemy, Kepler, Galileo, Huygens, Newton, Laplace, and Gauss, to mention only a few. Some comparatively recent mathematical astronomers, such as Leverrier, Adams, Newcomb, and Hill, are not discussed.

The reviewer was interested in learning that the one complete mathematical fragment of the Hellenistic period extant was written by the Ionian philosopher Hippocrates; it deals with the curiously impractical subject of "lunulae" — the little moons or crescents bounded by circular arcs. These lunulae also appear in the theory of eclipsing variables. Among other points of special interest might be mentioned the peculiar Egyptian calculus of fractions, the paradoxes of Zeno, the "series of Fibonacci," Kepler's computations of the volumes of wine barrels, the Newton-Descartes controversy concerning the flattening or elongation of the earth's poles, the pathetic figure of Galois, and the many brilliant mathematical developments of the 19th century.

It is a curious fact that toward the end of the 18th century some of the leading mathematicians expressed the feeling that the field of mathematics was somehow exhausted. This had its counterpart a hundred years later among physicists. The mathematical viewpoint was expressed by Arago who wrote:

"Five geometers—Clairaut, Euler, D'Alembert, Lagrange and Laplace—shared among them the world of which Newton had revealed the existence. They explored it in all directions, penetrating into regions believed inaccessible, pointed out countless phenomena in those regions which observation had not yet detected, and finally—and herein lies their imperishable glory—they brought within the domain of a single principle, a unique law, all that is most subtle and mysterious in the motions of the celestial bodies. Geometry also had the boldness to dispose of the future; when the centuries unroll themselves they will scrupulously ratify the decisions of science."

Today, of course, science does not so boldly dispose of the future.

JOHN B. IRWIN
Indiana University

NEW BOOKS RECEIVED

SCIENCE, SERVANT OF MAN, *I. Bernard Cohen*, 1948, *Little, Brown*. 362 pages. $4.00.

This book discusses selected case histories of some far-reaching discoveries of modern science, and shows how the search for basic scientific truths is productive of practical results for the average citizen.

THE ATMOSPHERES OF THE EARTH AND PLANETS, *Various authors*, 1949. *University of Chicago Press*. 366 pages and plates. $7.50.

Edited by Dr. Gerard P. Kuiper, director of Yerkes and McDonald Observatories, this volume includes papers presented at the 50th anniversary symposium at Yerkes in September, 1947. Latest discoveries in the study of planetary and terrestrial atmospheres are discussed by the authors, who are astronomers, meteorologists, and high-altitude specialists.

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SWEEPER IN THE SKY

Helen Wright. The Macmillan Company, New York, 1949. 253 pages. $4.00.

SWEEPER IN THE SKY is the biography of Maria Mitchell, the first woman astronomer in America, who lived from 1818 to 1889. More than half her life was spent on the island of Nantucket at a time when it was an important whaling and seafaring port. As a child Maria helped her father make observations of the stars in order to correct the ships' chronometers. At the age of 12, during her father's absence, Maria surprised a skeptical old sea captain by making the observations and recording the error of his chronometer exactly as her father would have done it.

For many years, in addition to carrying on household tasks and working as librarian of the Nantucket Atheneum, Maria with her father continued to make extensive observations of the heavens, using several small telescopes. Her formal education was followed by independent study of the greatest books on astronomy and mathematics. For some years she did astronomical work for the Coast Survey and the Nautical Almanac.

In 1847 she discovered a telescopic comet, which came to be known as the Maria Mitchell comet. In recognition of this discovery a gold medal was presented to her by the King of Denmark. This was only the first of several well-deserved medals, honorary degrees, certificates of merit, and elections to learned societies which Maria received during her lifetime. The author quotes Maria as saying that she was "born with only ordinary capacity, but extraordinary perseverance." Yet when the reader contemplates the remarkable achievements of this "lady astronomer" in a century when women were discouraged from intellectual pursuits and the professions, this seems a very modest remark.

The historical background, both general and astronomical, of the 19th century is well drawn. Maria Mitchell was an ardent advocate of women's rights and especially of higher education for women. Among many other activities, she served as president of the Association for the Advancement of Women. She traveled considerably in this country and twice to Europe, visiting the leading observatories there. Her contacts with American and European astronomers provide a good picture of the astronomical history of her time.

When Vassar College opened in 1865, Maria Mitchell was invited to be its first professor of astronomy and director of the observatory. There she proved to be a great and inspiring teacher, who taught more than the laws of Kepler and Newton. She taught a "way of life." Many college legends and anecdotes about her have been woven into the present story along with an account of her enthusiasm for research and the inspiration she gave her students. Delightful as the early part of the book is with its lore about Nantucket, astronomers will find the later chapters even more fascinating because of the accounts of observing rules and practices.

Three rules of observing, which Maria Mitchell gave to her students, might well be followed by students and amateur observers today: "Plan in advance what you desire to see . . . . Record all that you see — good or bad — weak or strong . . . . Be honest—avoid the temptation to see what you are expected to see . . . ."

During more than 20 years at Vassar, Maria carried on extensive research, particularly of the physical features of Jupiter and Saturn, double stars, and sunspots. She was the first in America to make a series of daily photographs of the sun, when the science of photography was in its infancy. All her research and observations she shared with her students and included remarkably keen speculations as to the answers future research would produce. Her research is the more to be admired in view of her limited equipment: "a pair of excellent eyes, an insatiable curiosity, and a telescope in need of repair."

The author of **Sweeper in the Sky,** herself a competent woman astronomer, has spent a number of years, especially at the Maria Mitchell Observatory on Nantucket and at Vassar College Observatory, doing the extensive research necessary to produce an excellent biography. The book is peppered with the quaint and charming colloquial expressions of Nantucket. Miss Wright has caught the spirit of Maria Mitchell and told her story with insight and sympathy.

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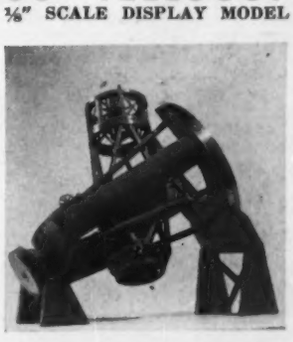

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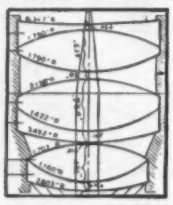

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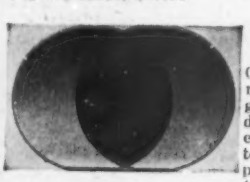

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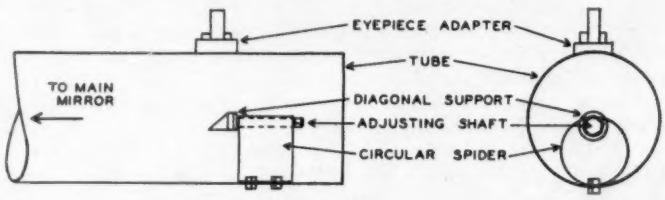
This reflector pattern has radial spikes. If either one or two legs are used to support the secondary, there are two spikes to the image; when three supports are used, there are six spikes, and when, as is most common, four legs are provided, there are four spikes. A particular case is the McDonald reflector photograph of Uranus reproduced on page 43 of **Sky and Telescope** for December, 1948. If the fifth satellite had, by chance, been in such a position that its image fell upon one of the radial spikes, it might possibly have escaped discovery at this time.

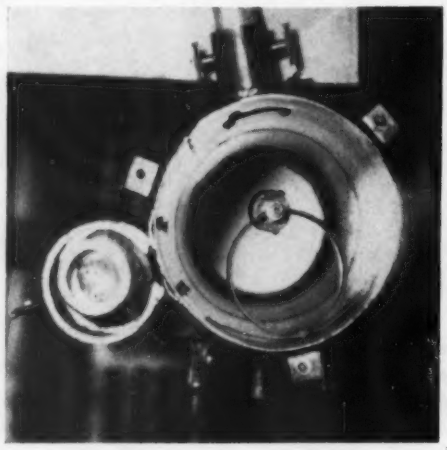
At low powers, star diffraction patterns are relatively unimportant and except on bright stars are absent to visual inspection. At high powers, however, these diffraction patterns interfere seriously with the resolution of the telescope as expressed in its ability to separate close double stars or to reveal fine planetary detail.

Following in principle the suggestions and experiences of professionals and amateurs in the past,[1] the writer has for some time been employing a variation of a type of secondary support that avoids the worst of the reflector diffraction effects. It consists of a circular member of one half the diameter of the main telescope tube, fixed rigidly to the tube with its axis parallel to the optical axis of the telescope, as shown in the photograph. The ring is rolled up from sheet steel 0.075" thick and 1½" wide, with the secondary support block welded to its circumference. Adjustment of the secondary is provided by a small shaft through the block and a clamping nut.



Side and end-on views of the installation of a circular support in R. R. LaPelle's 6-inch reflector.

[1]See **Amateur Telescope Making Advanced,** page 620, 1st edition, for the translation of an article by A. Couder concerning screening the arms of the spider, and the recent discussion in **Astronomical Information Sheets,** Mailings 101 and 102, 1948-1949, where various types of curved spiders used by amateurs are described.



A star's view of the circular support.

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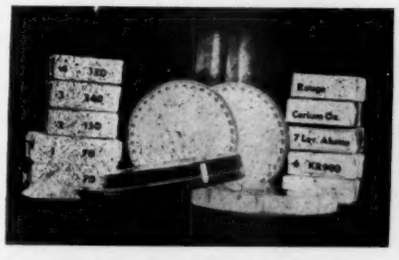

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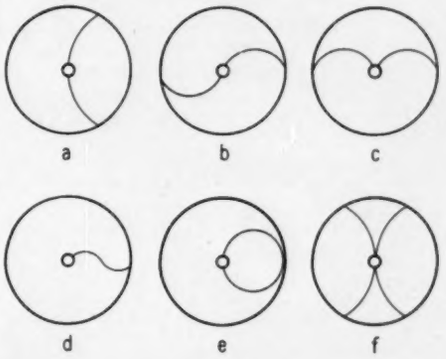
EDITED BY EARLE B. BROWN

The circular support may be bolted to the side of the tube or, as shown in the picture, first fastened to a strap of iron that is in turn bolted or riveted to the tube. The circularity of shape and rigidity are the principal requirements.

This support does not eliminate the diffraction. In fact, its effect is probably to increase slightly the size of the spurious disk and to lose some of its light, but it does eliminate the radial spokes and give a symmetrical image; the star diffraction pattern is not perceptibly different from that given by the refractor, and the writer believes it has helped him obtain high resolution in observing double stars and planets.

In books on telescopes we find repeated warnings against using too high a power. In order for the eye to perceive double stars as double, the images must be separated by 150 to 200 seconds of arc. If we assume Dawes' limit to determine the



This diagram of various types of circular spider is from Astronomical Information Sheets. Mr. LaPelle's secondary support is of type e, and Franklin B. Wright, Berkeley, Calif., suggests that type f is most efficient. Other amateurs have suggested or used types a to d.

expected resolving power of an objective, then the closest stars observable will be separated by an angle in seconds of arc of 4.56/**D**, where **D** is the diameter of the objective or mirror. For the observer to perceive the minimum separation of which the objective is capable, this apparent separation must be magnified to 200 seconds of arc. Hence, the minimum magnification to achieve this is 200**D**/4.56, or 44**D** per inch of aperture. For a 6-inch telescope this is a magnification of 264, and for a 10-inch it is 440.

Unless the focal length of the objective is unusually long, such high powers require eyepieces of uncomfortably short focal lengths, sometimes unprocurable. The writer finds the best solution to be the use of an achromatic Barlow lens[2] in combination with an eyepiece of normal focal length.

Nevertheless, such high powers as 44 per inch of aperture can be used only when the seeing is perfect, and then they require great patience and perseverance. However, granted these prerequisites, good mirrors may be expected to perform

[2]See **Sky and Telescope**, III, 7, 16, May, 1944, for a diagram and description of a Barlow lens.

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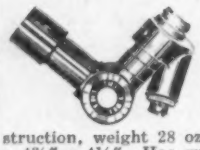

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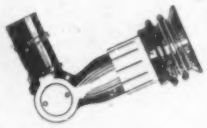

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up to or even better than Dawes' limit,[3] as mine has often done equipped with the circular secondary support. The Dawes' limit for a 6-inch is about ¾ of a second of arc, and I have observed Zeta Herculis (magnitudes 3.0 and 6.5), separation about one second, with a Barlow lens and ⅝-inch eyepiece to give a power of 265. Other close pairs are Gamma Coronae Borealis, Omicron Persei, Eta Orionis. One of the writer's favorites is Sigma Orionis, which readily becomes four at low power (4.0, 10.0, 7.5, and 7.0) but can be divided into eight stars, four blue and four yellow, at high power and with good seeing.

For planetary work, the increased resolution of the circular secondary mount is very useful. It is indeed a thrill, with a small homemade telescope, to be able to see the Martian polar caps, many of the major dark markings and even some of the "canals" that we have all read about.[4] The red spot and numerous bands and markings on Jupiter, detail both in the rings and on the ball of Saturn, and shadow features on Venus are within the reach of even a 6-inch mirror, provided it be well constructed, carefully mounted, and perseveringly used.

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[3] As resolving power is arbitrarily defined with relation to the diffraction pattern and the light used, different observers may find different resolving powers for the same instrument, in some cases thus even exceeding the theoretical resolving power. — ED.

[4] Whether or not a small telescope can actually show any of the canals of Mars is certainly open to debate. Competent professional observers, using large instruments, have argued vehemently over the existence of the canals for many years. — ED.

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OBSERVER'S PAGE

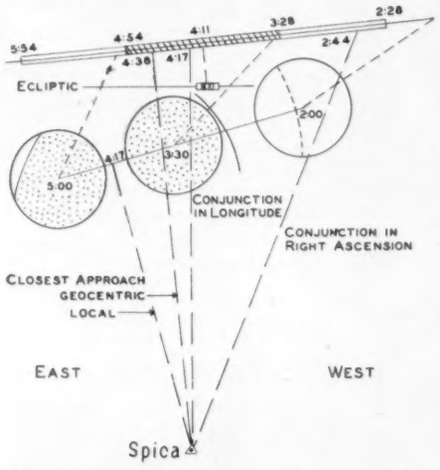
Universal time is used unless otherwise noted.

SPICA AND THE TOTAL ECLIPSE OF THE MOON

THE BEAUTY of the total lunar eclipse on the night of April 12-13, 1949, will be enhanced by the proximity of the moon to the bright star Spica. Throughout the United States, the phenomenon will take place during convenient evening hours, and the moon will appear closest to the star in the course of the umbral phases of the eclipse. Conjunctions of the moon with 1st-magnitude stars during an eclipse occur only on rare occasions. It will be in conjunction with Spica during a total lunar eclipse only once again in the 20th century, in 1968, when the expiration of a Metonic cycle brings another eclipse on April 13th, and that will be the last time for about 700 years.

In the present instance, the moon and Spica will have the same right ascension 16 minutes after the moon has entered the umbra of the earth's shadow. Because the moon's declination will be decreasing, however, conjunction in longitude will not occur until six minutes after the middle of the eclipse, more than an hour and a half later than conjunction in right ascension. Since the moon will be near its descending node, its closest approach to the star will take place even later than the conjunction in longitude. It will be only 16 minutes before the total phase ends that the separation of the moon and star will be a minimum.

All the above predictions are for a geocentric observer, the actual times at any given station varying as a result of the moon's parallax. In the United States, all of the computed conjunctions take place east of the meridian so that the effect of parallax will be to make the times of apparent conjunction come a little earlier. At the time of closest approach, the star will be within three lunar diameters of the moon's lower limb, the actual separation depending upon the observer's position.



Phenomena of the eclipse as related to Spica and as seen from Rochester, N. Y. Diagram by Paul W. Stevens.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

The diagram shows the configuration as it will appear in Rochester, N. Y. The upper bar gives the geocentric position of the moon's center during the umbral phases of the eclipse, plotted in co-ordinates of celestial latitude and longitude. Directly beneath it are the positions of the center of the earth's shadow, which moves only a short distance along the ecliptic at corresponding times. The lower line shows the apparent path of the moon as seen from Rochester. Here the angular diameter of the disk is drawn to scale, and the edges of the umbra and penumbra of the earth's shadow are indicated. The lines with short dashes connect the apparent positions with the corresponding geocentric ones. These represent the displacements due to parallax and are directed away from the observer's zenith. If the diagram is held so that one of these lines appears vertical to the reader, the position angle of the star is accurately reproduced for the particular time involved and with reference to the direction of the zenith at the local station.

A study of the proximity of the moon to a star during an eclipse immediately suggests the subject of occultations and the periods at which they occur. If the star or planet is near the ecliptic it may be occulted during the eclipse. Since the latitude of Spica is 2.1 degrees south, its conjunctions with the moon at the time of eclipse are relatively close and take place near the beginning or ending of its occultation seasons. The first occultation of the new series for that star comes on December 15, 1949. It is indeed possible for Spica to be occulted during a partial lunar eclipse, although it is too far from the ecliptic to disappear during a total eclipse. In April, 1987, it will be occulted in the course of an eclipse that will be either a partial or a penumbral of small magnitude.

Of all the 1st-magnitude stars, Regulus is closest to the ecliptic, and it may actually be hidden by the moon during a total lunar eclipse. Such a phenomenon shall not be for us to see, however, as the last umbral eclipse of a Metonic sequence near that star took place on February 20, 1943. On that night a partial eclipse was visible in the United States, while earlier on that date the star was occulted in the Southern Hemisphere. For about the next 700 years, eclipses in the constellation of Leo will take place east of Regulus until a new series begins in conjunction with that star.

An imaginative observer would enjoy a trip to the moon so that he might look back upon the earth at the time of this month's eclipse. He could hardly fail to be impressed with the glory of the spectacle. On the rim of our planet would be

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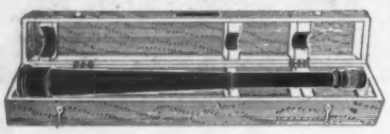

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The Skalnate Pleso ATLAS OF THE HEAVENS, designed and executed by Antonin Becvar and his associates, should prove invaluable to all amateur and professional astronomers. One of the charts, on a reduced scale, was reproduced and described in the November, 1948, issue of *Sky and Telescope*.

The atlas is printed on 100-pound stock, each chart area 15½ by 23½ inches. A title page, descriptive matter and a chart key are included. The set is shipped rolled, in a heavy mailing tube.

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a very thin but luminous red ring due to the passage of sunlight through our atmosphere. Beyond this, the sun's outer corona would be seen. There would be no 1st-magnitude star in the immediate vicinity, but crowning the beauty of the eclipse would be the bright planets Venus and Mercury within one degree of each other, while a little to the west would be ruddy Mars. Mercury is in superior conjunction with the sun on the day of the eclipse; Venus follows three days later, while the mutual conjunction of these two planets occurs a day earlier than the eclipse.

PAUL W. STEVENS
2322 Westfall Rd.
Rochester 10, N. Y.

NOTES ON THE ECLIPSE

The Western Hemisphere has not been treated to a total eclipse of the moon for 3½ years, but this year we have two such events. The first, on the evening of April 12th, may be considered the better. The moon will be at perigee on the 12th, 222,500 miles distant; the earth's umbra is larger, the penumbra smaller, at that point. The eclipse is generally visible in North and South America, Europe, and Africa. Shortly after twilight ends on the East Coast, the moon enters the penumbra, which is difficult to observe. Just before contact with the umbra of the earth's shadow, however, the moon will look somewhat darker along its southeastern edge. Totality will be one hour 26 minutes long — the greatest duration possible is one hour 40 minutes. Five hours and 19 minutes will elapse between first and last penumbral contacts, as the following table of events, for April 13, Universal time, shows:

Moon enters penumbra	1:31.6
Moon enters umbra	2:27.7
Total eclipse begins	3:28.0
Middle of eclipse	4:10.9
Total eclipse ends	4:53.8
Moon leaves umbra	5:54.1
Moon leaves penumbra	6:50.3

Penumbral observations before and after the eclipse, visually and photographically, are wanted by Dr. Alexander Pogo, Widener Library, Harvard University, Cambridge 38, Mass., while Lewis Lindsay, 2217 Mission St., San Francisco, Calif., suggests observations of the colors of the eclipse. One may refer to his article, "Color Sequences in Lunar Eclipses," on page 16 of **Sky and Telescope**, November, 1945. He writes:

"The important points to be covered are the colors and shadows, the time at which they shift or change, and the altitude and location of the observer. Observations are wanted at higher elevations, especially in the Colorado region of the Rocky Mountains and in the High Sierras. After a definite relationship can be established between altitude and color, it then may be possible to correlate these variations of shadow and color with atmosphere and weather conditions prevailing upon the twilight rim of the earth at the time of eclipse."

Photography may be attempted, preferably with a telescope. The partial phases should not be difficult. The full moon requires an exposure of less than half a second, but photographing the totally eclipsed moon will be tedious except for instruments equipped with slow motions. Focal plane pictures or projected images may be used. Red-sensitive film should help record the ruddy umbra, and good results may be obtained with color film. A series of images on one frame to show the progress of the eclipse is always impressive.

EDWARD ORAVEC

MOON PHASES AND DISTANCE

First quarter	April	6,	13:01
Full moon	April	13,	4:08
Last quarter	April	20,	3:27
New moon	April	28,	8:02
First quarter	May	5,	21:33

	April	Distance	Diameter
Perigee	12d 9h	222,500 miles	33′ 22″
Apogee	24d 22h	252,200 miles	29′ 26″

APRIL METEORS

The Lyrids, an annual meteor shower, are at maximum on April 21st. The total duration is three to four days, but the shower is seldom good except on one night. The radiant is 10 degrees southwest of Vega, and rates of five to 10 per hour are usual after midnight. The Lyrids are swift, and the moon will not interfere, being at last quarter.

E. O.

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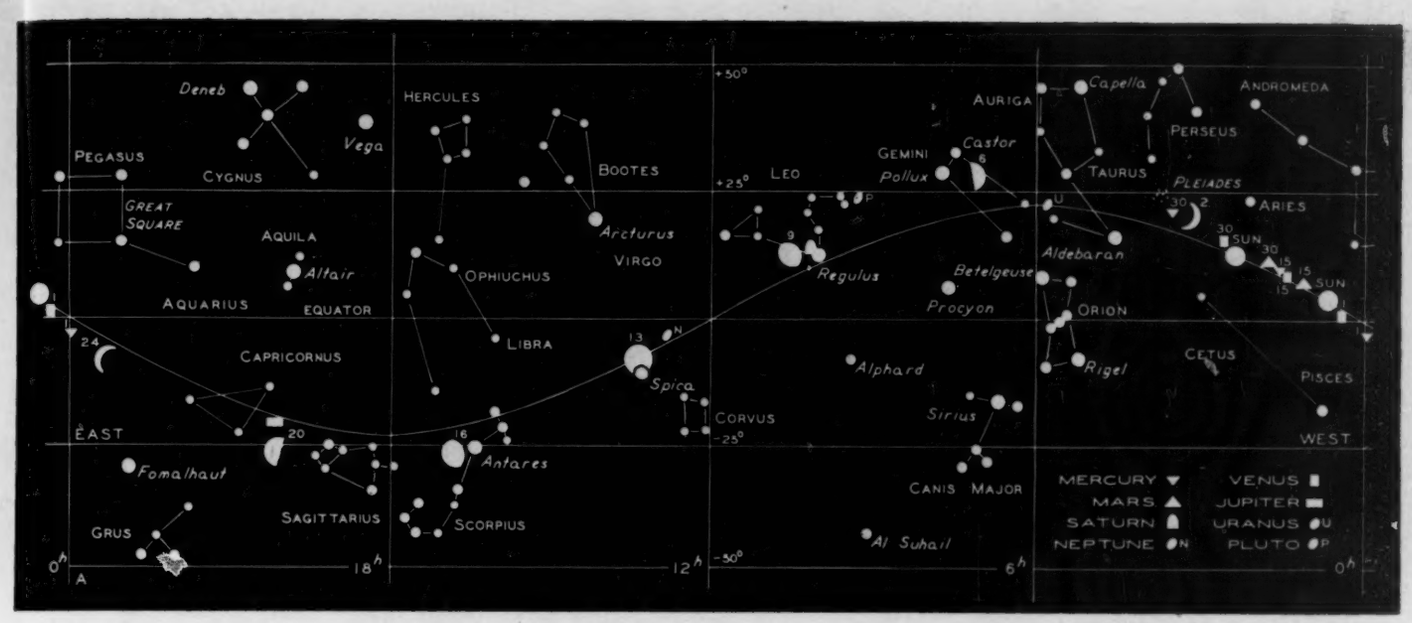


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Sun. A partial eclipse of the sun occurs on April 28th, invisible from the United States, but observable in North Africa, Europe, Greenland, and parts of northeastern Canada and Siberia. At maximum, the sun will have 61 per cent of its diameter covered, at sunrise in Davis Strait.

Mercury begins the month as a morning star, passing superior conjunction on April 13th. The last few days of the month find the planet setting 1½ hours after the sun, of magnitude −1, and easily visible. The 1½-day-old moon will be near Mercury on April 29th, and after noon at the Vancouver standard station there will be an occultation of the planet.

Moon. Phenomena involving the moon this month include a total lunar eclipse and occultations of Antares and Mercury, described elsewhere in this department.

Venus passes the sun in superior conjunction on April 16th, and is invisible throughout the month.

Mars cannot be seen, as it is too near the sun.

Jupiter rises 3½ hours before the sun, in Capricornus.

Saturn is approximately a degree north and east of Regulus, in Leo. Its magnitude is +0.6, twice as bright as the star.

Uranus sets several hours after sunset; with optical aid it may be found moving eastward between 132 Tauri and 1 Geminorum, nearer the former. The planet is of the 6th magnitude.

Neptune reaches opposition on April 3rd, position $12^h\ 53^m.5$, −3° 58′ (1950), and it is of magnitude 7.7. The planet is moving westward between 44 and 38 Virginis.

E. O.

VARIABLE STAR MAXIMA

April 2, R Virginis, 6.9, 123307; 9, R Phoenicis, 7.8, 235150; 16, R Cancri, 6.8, 081112; 18, R Cygni, 7.3, 193449; 21, R Hydrae, 4.6, 132422; 23, T Centauri, 6.1, 133633; 29, R Lyncis, 7.9, 065355. May 3, T Cephei, 5.8, 210868; 6, S Virginis, 7.1, 132706; 7, V Coronae Borealis, 7.4, 154639.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

OCCULTATION PREDICTIONS

For the eastern and central United States and Canada, Antares is occulted by a 17-day-old moon on April 15-16, which is a Friday night so one may not mind staying up well after midnight to view immersion on the bright side of the moon. Emersion on the dark side should be a striking event, taking place an hour or more after immersion at most of the standard stations.

At Vancouver just after noon on April 29th, Mercury will be occulted by a thin crescent moon, about 15 degrees east of the sun. For Calgary the British **Nautical Almanac** lists a grazing occultation. A good telescope, mounted well, with circles for finding the faint lunar crescent in the bright sky near the sun, may permit observation of this event.

April 1-2 **Delta Arietis** 4.5, 3:08.7 +19-32.1, 3, Im: **G** 3:37.5 −0.3 −0.8 63; **H** 3:58.6 +0.1 −2.6 120; **I** 3:35.1 −0.5 −1.1 73. Em: **H** 4:43.6 −0.5 +0.8 213.

April 4-5 **136 Tauri** 4.5, 5:50.1 +27-36.1, 6, Im: **A** 3:56.0 −0.1 −1.0 80; **B** 3:52.9 −0.2 −1.0 75; **D** 3:54.0 −0.2 −1.2 86; **E** 3:57.3 −0.2 −1.8 110; **F** 4:19.4 +0.8 −3.4 152; **G** 3:23.9 −1.0 −1.8 106; **I** 3:17.2 −1.2 −2.1 117. Em: **A** 4:48.7 +0.5 −1.4 290; **E** 4:56.0 −0.1 −1.0 262; **F** 4:55.5 −1.3 +0.8 222.

April 15-16 **Alpha Scorpii** 1.2, 16:26.3 −26-19.2, 17, Im: **A** 6:41.2 −1.5 −0.1 120; **B** 6:39.6 −1.4 +0.1 117; **C** 6:35.7 −1.2 −0.3 132; **D** 6:32.4 −1.1 0.0 127; **E** 6:25.2 −0.2 −0.8 155. Em: **A** 7:59.2 −1.9 −0.3 280; **B** 7:56.4 −1.7 −0.3 283; **C** 7:50.3 −2.1 0.0 271; **D** 7:46.1 −1.8 +0.1 276; **E** 7:20.4 −2.3 +1.2 253.

April 29-30 **MERCURY** −0.6, 3:33.8 +21-17.3, 2, Im: **I** 20:03.9 ... ... 122. Em: **I** 20:49.6 ... ... 178.

May 2-3 **49 Aurigae** 5.0, 6:32.0 +28-03.8, 5, Im: **F** 2:41.6 −1.3 −0.2 67. Em: **F** 3:33.0 +0.4 −2.3 319.

May 3-4 **Upsilon Geminorum** 4.2, 7:32.8 +27-00.7, 6, Im: **H** 2:54.0 ... ... 38. Em: **H** 3:17.8 ... ... 0.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, all data from the American Ephemeris and the British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

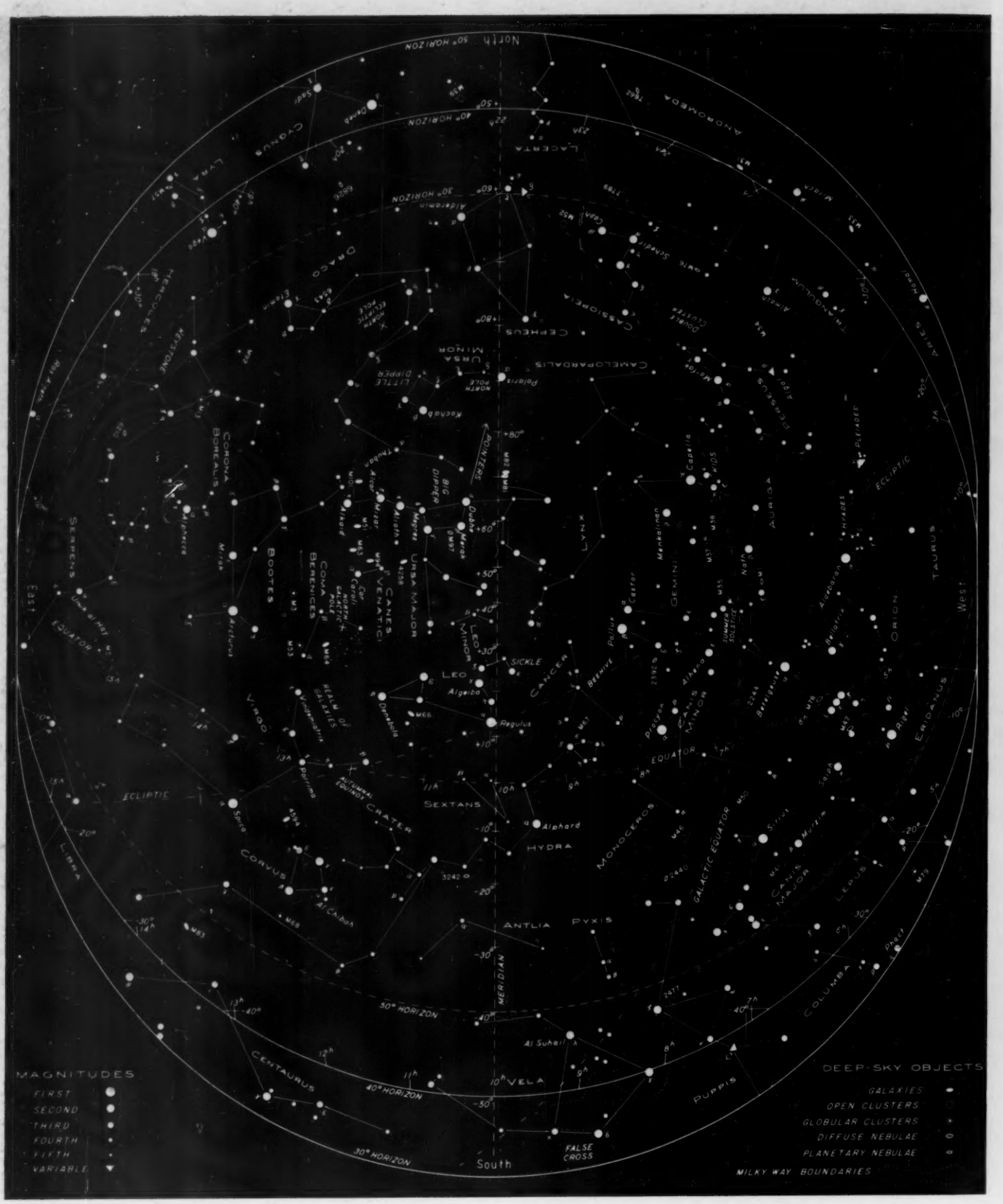
Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +30°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your own standard time.

MINIMA OF ALGOL

April 1, 13:52; 4, 10:41; 7, 7:31; 10, 4:20; 13, 1:09; 15, 21:58; 18, 18:47; 21, 15:36; 24, 12:25; 27, 9:14; 30, 6:04. May 3, 2:53; 5, 23:42; 8, 20:31.



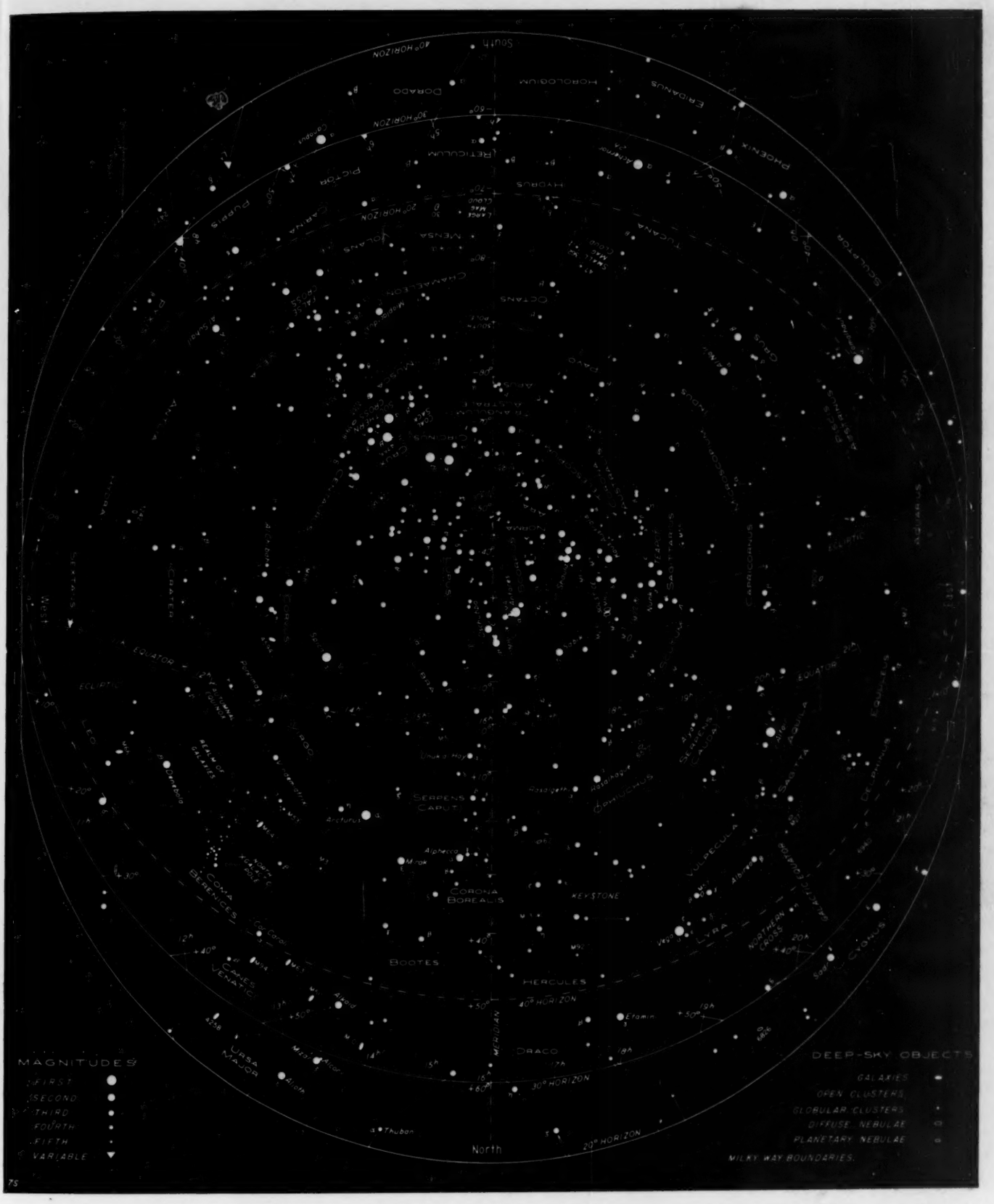
The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of April, respectively.

STARS FOR APRIL

WITH THE BIG DIPPER high in the sky during spring evenings, beginners in observing may readily use the signposts that this large and widely known star group supplies. The Pointers in the front of the Dipper's bowl lead the way past the tip of Draco's tail to Polaris, the North Star. Extend the line between Merak and Dubhe about five times its length to reach Polaris, a 2nd-magnitude star. From there, the Little Dipper stretches back toward the Big Dipper's handle. The two stars at the end of the Little Dipper are easy to find, but a good sky and careful observation may be necessary to identify the Little Dipper.

The handle of the Big Dipper is the Great Bear's tail. Extend its curve eastward and southward to the 1st-magnitude Arcturus, at the foot of the kite-like configuration of Bootes, and the same curve continued about the same distance farther leads to Spica, a star close to the ecliptic. It is one star in the "diamond of Virgo," the others being Arcturus, Denebola, and Cor Caroli.

The Pointers lead southward into the center of Leo, a constellation of two distinct parts: the Sickle, with bright Regulus at the end of its handle, and a triangle containing Denebola, in the Lion's tail.



The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively.

SOUTHERN STARS

TWENTY stars in the entire heavens are of the 1st magnitude, 60 are 2nd-magnitude objects, while there are 180 stars of the 3rd magnitude. In a roughly oval region of this chart from Centaurus to Sagittarius, constituting but about a tenth of the area of the celestial sphere, may be counted five 1st-magnitude, 14 2nd-magnitude, and about 45 3rd-magnitude stars, a high concentration of stellar brilliance.

In addition to thus containing one quarter of all the bright stars, this part of the Milky Way is festooned with the brightest of star clouds, the best dark and bright nebulosities, and scores of clusters.

Scorpius-Centaurus and company dominate the sky for Southern Hemisphere observers during June and July. (For the earlier month, chart times are 11 p.m. on the 7th and 10 p.m. on the 23rd.) In addition to easily identified Scorpius, Sagittarius, Crux, and Triangulum Australe, there are vast Centaurus, populous Lupus (the Wolf), and distinctive Ara. The minor configurations of Circinus, Corona Australis, Musca, Norma, and Telescopium bring the number of groups in the area to 12, over one eighth of all the constellations in the sky. A few stars from other groups fall within the region of count also.

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